NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XIV. December, 1899. No. 2.

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SOME NOTES ON THE DESIGN OF WATER WORKS DISTRIBUTION SYSTEMS.

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[*Read September 15, 1899.*]

It is perhaps a little surprising that a more or less thorough search of some ten years' duration through the various works on Hydraulics and Water Supply Engineering has failed to discover in the English language a satisfactory chapter upon the Distribution of Water. As a recent writer upon the subject has said in substance, it seems as if engineers and writers had considered the matter of such small consequence as to be unworthy of special discussion. Because I doubt if any of my hearers have had better success in similar quests than myself, I have determined to take a few moments for outlining briefly some of the essentials of the question.

So far as I have been able to discover, the writers upon this subject have generally assumed that all territory is flat except a convenient hill upon which the hypothetical reservoir is situated. In practice, unfortunately, we do not find things that way. Our cities ordinarily have considerable variations in surface elevation within their limits, and it not infrequently happens that as high a pressure may be required upon the high as upon the low levels. Many times this problem is solved by giving the high level the required pressure and making pipes and plumbing in the low levels strong enough to stand the excess. This is about as sensible a proceeding as it would be to design the plumbing of a house so that fire must be kept in the furnace all summer to furnish hot water for washing dishes. It costs

money to pump water, and the higher the head, the greater the cost. When the territory to be supplied is made up of two distinct levels it is sometimes best to introduce high and low pressure systems. There is, however, usually an intermediate level which unites the high and the low, and does not clearly belong with either, that must be provided for; or it may be that the differences of elevation are too small, or the consumption too low, to warrant a division of the system, and we, in either case, have a problem similar to that involved in the plumbing of a high building without using a tank at its top. Few of us would think of attempting to supply fourth and fifth floors from the same riser that supplies first and second stories, although the water may all be taken at the same pressure at the curb, and certainly none of us would carry a riser to fixtures on the fifth floor and then down to others on the third. So in the larger case of the water works distribution, it should not be attempted to supply high and low levels from the same main if a nearly equal pressure is desired in the two places, nor especially should water be pumped over a summit to low levels and an effort made to supply the summit from the same line. As a corollary to this we may add that water should not be pumped to high ground and then allowed to flow away unrestricted to lower levels. In the latter cases, from the well-known principle of the *hydraulic gradient* it is entirely possible that although the head at the source or the pumps may be considerably above the summit, the consumption below and beyond it may be so great as to entirely destroy the pressure at the high point.

It should furthermore be remembered that the resistances to flow increase pretty nearly as the length of the line, and hence that the most direct route, due consideration being given to grade, should be chosen for the line to supply a given district. In general, the main supplying sloping territory should run near its lower side, as this insures against a summit in the line between the source and the point of consumption. Carrying these principles to the extreme, the distribution system might be compared to a river and its tributary streams with the current reversed. Each tributary and its branches would then be supplying a different level, and there would be no connection between the subsystems. Practically, there are objections to this extreme treatment, and the above principles must be modified to the extent of connecting the subsystems by cross lines, and the individual small mains must also be laced together in order to furnish proper fire protection. The cross lines from sub-

system to subsystem must be arranged with care. If they are to be large, which should be avoided as far as possible, they should be shut off at both ends by gates, to be opened in case of emergency. It is usually better to make these connections by small mains which decrease in size as they depart from the trunk lines, and by which the friction and local consumption tend to prevent an extensive flow from one part to another, except in cases of a large difference of head. In small cities the necessity for cross lines from subsystem to subsystem is greater than in large ones, because in the former the fire requirements stand in a higher ratio to the other demands than they do in the latter. In the large cities each subsystem should be designed to provide for any fire within its limits. In the smaller city this cannot be done, as it would entail excessive expense. So in the former the cross line is needed only in case of a break in the main supplying the adjacent subsystem. These cross lines, if of large capacity, are a never-ending source of trouble where a fine adjustment of pressure is required, for if they are left open such adjustment is impossible, and if they are closed at one point only, they become receptacles for sediment which may under some conditions be decidedly detrimental to health, and will, in any event, be distributed to the consumers whenever the line is opened. Therefore the best treatment is to shut them off entirely, or else arrange them to act as mud drains for the system and blow off their accumulations frequently. Similarly, the cross lines joining parallel mains in which an equal total pressure is maintained must be handled with care, for the only cause inducing a flow through them is the consumption from them; and this is where, whatever enthusiasts may say to the contrary, there is a proper place for 4-inch, 3-inch, and even 2-inch pipe in a well-designed distribution, for the lines of this class, if only one square long, should be designed to supply nothing more than the consumption to be taken from them. They then become the lowest element of the system, for they have no bearing on that which is beyond; these lines are made too large more frequently than too small, and it is often difficult to tell which is the greater evil.

The proper gating and draining of a system is a very important matter. Gates should be set at intervals sufficiently frequent to prevent large areas being shut off in case of breaks. About 1,000 to 1,600 feet apart for large mains, 16-inch and above, and 600 feet for small mains, 8-inch and under, is good practice. No shut-off should require the closing of more than eight gates if it can be avoided. It

is often wise to use two tees with a gate between in place of a cross. Large mains may well be gated with gates at least one size smaller than the pipe, a reducer being used at each side of the gate. This is economical in cost and saves time in shutting off, while the additional loss of head will be small. Blow-offs should be provided, if possible, to drain each section between gates on large mains, and large ones of sufficient capacity to create velocities of from 5 to 10 feet per second should be so located as to enable every large main to be easily cleaned out. The most satisfactory arrangement for these is to make the pipe leading to the blow-off gate one or two sizes larger than the gate and several feet long — anywhere from 12 to 50 feet is good — joining the main it is designed to clean by a Y, whose opening is on the same level as the bottom of the main. The Y should be set so that the direction of flow is toward, not away from, its oblique branch. This arrangement insures a large amount of sediment being caught in the connection to the blow-off which is washed out of the system as soon as the gate is opened. It is, in fact, about as satisfactory a scheme for trapping mud as has been devised. In paved streets it will usually pay to enclose the gates in wells sufficiently large to admit a man to make repairs, for, like all other machines, gates get out of order. It is also well to provide manholes affording access to the interior of large mains at frequent intervals.

Pipes should be laid as nearly straight as possible, both vertically and horizontally. Curves where used should be of not more than five diameters radius and preferably of only three or four. Long, so-called easy curves should never be used, as they greatly increase the losses of head. The side openings of branches ought to approximate to the form of the *vena contracta* and the smaller lines should be taken from the top, not the center or bottom, of the larger, as this insures less sediment and foreign matter in the water as it goes to the consumer. This is particularly important where meters are used. When the direction of flow is determinate and uniformly in one direction, Y's are preferable to T's for branch connections. The direction of flow should be maintained constantly in one direction for each section of pipe if possible, and provision should be made for proper circulation in all lines. Dead ends and short dead loops must be avoided if possible, and the larger they are in diameter, the worse the condition if they exist.

The foregoing remarks apply especially to a pumping system or

to one in which the reservoir is situated across a valley from the town. They would not all necessarily apply to the case of a city on the slope of a hill, at the top of which the reservoir is located.

DISCUSSION.

MR. KUICHLING. There is one thing I think Professor Williams should explain, and that is the matter of the resistance of curves. He has made some of the most interesting and beautiful experiments that have ever been made in hydraulics, and the result of them is his apparent heresy as to the resistance of curves. This is a novelty, not to be found anywhere in hydraulic literature. It is confined now exclusively to Professor Williams' mind. I do not think it has appeared in print or even fully in manuscript as yet. I therefore ask Professor Williams to supplement his paper by a brief reference to his apparent heresy.

PROFESSOR WILLIAMS. There may be some other discussion of this paper, and I should prefer to reply to all the discussion at one time, and therefore I will wait a few moments before complying with the request of Mr. Kuichling.

MR. HASKELL. We have all been in the habit of considering that a straight line would give the least resistance, and the least deviation from a straight line would be, of course, the easiest curve. I don't know but it will be very easy to explain it to our minds in such a way that we will understand that the least deviation would present the greatest resistance. But there is one thing I would like to say in connection with the paper. We have not been in the habit of figuring quite so closely on the sizes of our pipes as the paper would perhaps lead us to do. Our reason for that is principally this: that in designing works we do not consider that the first demand is to be the full capacity of the works. The demand is supposed to increase, and there will be a much greater consumption later on than at the time the works are designed. If we should construct a system as absolutely perfect as possible for the present, the increased consumption in the future would demand the construction of a new system. Also it is a fact that a good many tubercles form in our pipes, no matter how nice the inside coating is. I have known a 4-inch water pipe reduced to an effective diameter of less than two inches; so that it is utterly impossible to bring the original construction of a works down to absolutely the best size for the works at the time. And I

think if we should confine pipe that has got to supply a hydrant to not less than six inches in inside diameter, we would n't make a very bad mistake. In case a pipe is fed in both directions, a 4-inch pipe would probably be ample, if not too much tuberculated. But we can't figure in the construction of a water supply system for a city down to the most economical point for the present time; we have got to allow quite a little margin for the future.

MR. MCKENZIE. Mr. President, there is one thing which I noticed, and that is that Mr. Williams recommends that the branches be taken off the mains at the level of the top of the pipe, or, rather, that what we call the blow-off should be reversed, so it will leave at the level of the top of the pipe, to prevent the sediment from getting into the meters. I should like to know whether that is merely a theory, or whether he has observed it in practice, and I should also like to know if castings are made in that way.

MR. WILLIAMS. I will answer that question directly, Mr. President, by saying that is the practice which was introduced by myself, and has been found to give extraordinarily good results in Detroit, and that all of our specials are designed with that in view. They were re-designed after my connection with the works. I really have no right to say that this practice was introduced by me, because my predecessor had introduced it on the larger mains; but I carried it to a greater extent than he did by extending it to the very small sizes. Where we take a 4-inch out of a 6-inch I would have the top of the 4-inch at the same level as the top of the 6-inch.

MR. HAZEN. I don't know the history of it, nor who is responsible for it, or anything about it, but I have seen castings of that description around the streets of New York on a great many occasions for a considerable period, and I know that they are common.

THE PRESIDENT. Are there any further questions to be asked of Professor Williams?

MR. WALKER. Mr. Williams says it does n't make any difference if you put an 8-inch gate into a 10-inch pipe. Well, if that is all right, then I have been all wrong all the days of my life. [Laughter.]

MR. FISH. It is all right, and I say that from the fact we have had it exemplified in the Venturi meter. They will take a Ventur meter and bring down a 30-inch pipe to 12 or 16 inches in diameter, and they say and have proven that it is accurate. They reduce the size of the pipe more than one half, and they say there is no diminu-

tion in the volume of water, and I don't know but we have got to accept it. I don't know whether there is any gentleman here who is acquainted with the operation of the Venturi meter; but you may take a service pipe if you please, for a good illustration of it. and insert a ½-inch corporation cock, as we term it, and run a ¾-inch pipe from that 300 feet, and you may take a ¾-inch service cock and insert that and run the same distance with a ¾-inch pipe, and you can't tell which is which at the end.

MR. WALKER. Will somebody please help me out? [Laughter.]

MR. HASKELL. Mr. President, I have often attempted to help Mr. Walker out on all sorts of questions he has asked me, and I will try to help him out now. And I think the best way to help him out will be to show him how to satisfy himself that this statement is correct, and I think I can do so if he has a special gage attached to any of his pipes. Of course after he has tried the experiment he will let us know whether I did help him out any or not. Now one way that he can determine this question is this: open the gate to a pipe, be sure it is absolutely fully open, look at your gage, and then close the gate and keep closing it until you see that you are losing your pressure.

MR. FISH. That will be half way.

MR. HASKELL. Will you please let Mr. Walker tell us. It may be a great deal more than half way, depending upon the consumption. If they were only using an amount of water from that pipe which would go through an inch pipe, you could close the gate down until the area was equal to even less than an inch, because the friction at the gate is only for the thickness of the gate, and through the pipe the friction would be for the entire length of it. If you opened the outlet to the pipe and allowed quite a large body of water to go through, you would begin to feel the difference in closing the gate much quicker. So the statement is more nearly correct than people would at first think, that you can put an 8-inch gate into a 10-inch pipe and not affect the amount of water flowing through it very materially, and if Mr. Walker will try this experiment I think he will demonstrate the truth of the statement to his own satisfaction.

MR. HAZEN. Mr. President, some time ago I had the pleasure of looking over the Rochester water works with Mr. Kuichling. He was taking water from Hemlock Lake down to the city through a pipe 38 inches in diameter, and he was filling this pipe and supplying the city through one of his by-pass gates 8 inches in diameter.

The water went through under a high pressure very rapidly, filling the 38-inch pipe and supplying the city of Rochester. I have never been able to understand how Mr. Kuichling convinced the City Council that an 8-inch pipe would n't do all the way down. [Laughter.]

MR. KUICHLING. Mr. President, I did n't convince the Council; I left that out. The contract was too large for me. I presumed it would need a good staff of surgeons to accomplish that result. [Laughter.] So I contented myself with simply making a prescription, and then said to those who did n't understand, "If you don't want to take it you can get another doctor." That was a simple way to manage that.

With regard to the operation of an 8-inch by-pass placed on a 38-inch pipe line, I may say that that pipe line is simply called upon now to do about one fourth or one fifth of its ultimate duty. There is out of a twenty million gallon ultimate consumption at present only about four or five million gallons required, and through the desire on the part of the municipal administration to be economical, devices for measuring the supply or delivery of the conduits have not been furnished, and the water works department has therefore been required to make use of a water gate as a water meter. We therefore calibrate an 8-inch by-pass for convenience of manipulation, instead of a 36-inch valve, as a meter. So many turns correspond to a rate of flow of so many million gallons per day or cubic feet per second, and in that way we keep track of the amount of water furnished.

But the matter of loss of head through gates or meters of any kind is the question at issue here, as raised by Mr. Walker and the preceding speakers. That is all there is to it — a question of loss of head, and how much we can stand. At the Rochester water works 40 feet, 50 feet, or even 60 feet of head may be lost, because only one fifth of the ultimate capacity of the pipe is now required. In the future, when the whole head may be required, there will be nothing to spare, and the main valve will be used to its full opening.

The matter of using valves as meters is comparatively old now. It has been used by others beside myself for a good many years. I have calibrated a 24-inch valve as a meter, I have several 16-inch valves as meters, a 20-inch valve, and several 8-inch valves on by-passes. Mr. J. Waldo Smith, of the Paterson works, has done the same thing with even larger valves. The experiments that he and I

have made on the matter, which are very exact, show that with a pipe of 30 or 36 inches diameter, 24 inches or 16 inches in diameter, when supplying water at full capacity with velocities of from 3 to 4 feet per second, the valve may be closed perhaps one half its travel before any noticeable loss of head is going to take place. The resistance in passing through the valve will be only in a length of the 3 or 4 inches occupied by the valve. Now one such resistance, or loss of head, will perhaps cut no figure whatever at the end of a long line of pipe. On the other hand, when you apply that principle through several hundred valves in a large city distribution system, you will have an aggregate loss of head amounting to so much that it will affect the usefulness of your system very materially, and especially at the time when its ultimate capacity is reached. In the early days of its use the loss may not be felt; but later on, in ten or twenty years, when the pipe is tuberculated, encrusted with various growths, its capacity reduced in some manner or other, then these losses of head begin to be appreciable, and it may not therefore be an expedient thing to do on a large scale. A few instances, however, amount to little. There is more daily fluctuation in the water level of the distributing system of any city I know of than the loss of head from perhaps two or three dozen reductions caused by using smaller valves than the diameter of the pipe; but that practice has got to be stopped after a time. In designing the larger distribution system for our city the number of valves accumulated, owing to the long length of the feed lines, to such an extent that I did not apply the principle of using a smaller valve than the diameter of the pipe. I had no head to spare. I had to serve high ground at a long distance from the reservoir, and I did not think it was advisable to lose 8 or 10 or 15 feet head in the aggregate. That head had a commercial value much greater than the saving in cost on the valves. A few hundred dollars saved in that way would be of no consequence in comparison with the value of serving hundreds of buildings, perhaps, on an additional story. The cost of pumping in those buildings to the additional story is so much greater than the interest on the saving that it becomes of course absurd to talk of it. But in the abstract, as Mr. Fish has put it, the work can be done, as stated by him, through a smaller valve, by tapering the pipe on each side. The illustration of the Venturi meter used by him is perhaps not quite in point, because the general form of the contracted vein of the issuing jet of water requires a very long taper on one side, the

discharge side, and a relatively short taper on the in-flow side. That in practice would be rather costly to introduce in a distributing system. The principle, however, has been availed of often, and by engineers who understood the matter thoroughly and knew what they were about, and it is common practice; and where only a few valves are concerned it is a good practice. But one must be a little careful not to apply the principle loosely, for that will hardly do.

MR. MCKENZIE. I would inquire of Mr. Williams if he would really recommend the use of smaller valves than the pipes in the construction of a distributing system with a view to economy in the matter of the cost of construction. Would n't the expense of the reducers on each side of the gate, and of the extra joints which would have to be made, be equal to the difference in cost of the gates?

MR. HASKELL. I would like to ask Mr. Kuichling what the least percentage of error is in measuring water passing through a gate, as determined by his experiments. If we can get it down to one per cent, it is quite an important matter, or if we could even get it down to 2½ per cent it would be quite important.

MR. KUICHLING. In answer to that question, Mr. President, I will say we get it without any percentage of error. We get it exactly, as exactly as it can be measured with any device at any time. Of course, the season of the year makes some difference in the flow of water, but barring that it is simply a question of accurate calibration. Like your pressure gage, it will indicate exactly every time, as long as the conditions remain the same. By noting the difference in pressure, or the number of turns that the gate is open, and measuring the discharge at a number of points, we obtain a curve of discharge, so that when we have, for example, the gate opened 5½ turns, or 5¼ turns, or any fractional part of a turn, if our diagram or table is correct enough, we can read it off as closely as we please. It is wholly a matter of convenience. A large diagram would enable you to read to very small quantities, and for convenience it may be reduced in size. That is all that amounts to.

Of course the calibration of a gate is done with a known discharge, the discharge and the head being measured at the same time; that is, at one experiment. In our city we repeat that once every year in one important gate which is now used for experimental purposes. For example, we want to know the coefficient of friction in a pipe line 38 inches in diameter and 10 miles long. We want to know what that coefficient of friction is with a very small velocity and very

small discharge; in short, a loss of head of only perhaps 4 or 5 inches in the whole length of the line. The gate is then calibrated for that discharge, and we adjust it in the way that I have indicated.

MR. HASKELL. My object in asking that question was really to see if we had found the perfect meter. We have been expecting any day to have somebody come around and introduce to us the perfect meter, one a little better than anything we have yet had. Now we want a meter for one of our force mains. We have a 30-inch pipe which delivers water from our pumping station into our reservoir, and we sometimes wish we knew just what the slip of the pumps was. We have gates situated on that line. We have tried to get the Venturi meter in there, but they want quite a large sum for it, and they don't get down to one per cent in their promises of measuring, and we can get down to within one per cent in another way. Now if there is any way in which we can work our gates in as meters to help us out as a check on the slip of our pumps it will be a great benefit to us, and I think every member of the Association would like to know it. It seems to me to be a pretty important thing.

MR. KUICHLING. I should like to reply to Mr. Haskell's question as to the use of a valve for a meter. It is an exceedingly cumbersome and tedious process to get the physical characteristics, the personal equation as you might term it, of a particular stop-valve. When you have got it, however, and the valve is not spoiled, or the conditions are not spoiled by accumulations of rust or various growths that may take place in it, the characteristics, so to speak, of the particular valve will remain the same. With pumping works and the variations in pressure due to the pump, perhaps things will be a little more difficult to manage than with the constant pressure of a gravity supply. It would be necessary then to know not only the characteristics of the valve for a particular pressure, but for a range of pressures, and the complexity of the operation increases in proportion to the variation to the pressure to be encountered. The coefficient of discharge may not be constant for all ranges of pressure, and that is a thing to be determined in each case by experiments, and these experiments are tedious. It means in our case a week or two weeks' work for a pair of my assistants, who are very rapid mathematicians, and it would probably mean for a man who did not use logarithms a good deal longer time. If he had to do it by the long method it would probably take him a couple of months. That of course makes it impracticable for general use. You use a gate or a

valve as a meter when you can't do anything else, and not from choice.

MR. HASKELL. That answers my question precisely. I thought in the case of a 30-inch pipe, where the expense of a meter would be quite large, that if your computations were not too elaborate we might be able to use them.

PROFESSOR WILLIAMS. Mr. President, I think I may be permitted to so transgress the rules of some deliberative assemblies as to make a statement at this moment in regard to my personal history, as I have desired for some time an opportunity to pay a compliment to a gentleman for whose ability I have the highest respect; and I wish to say that whatever I have accomplished in the way of experimental work, the bulk of which has not yet been published, but which I hope will be one of these days and not very far hence, is very largely due to the gentleman who was the first to discuss my paper this morning. When I, for the second time, turned my attention to hydraulics, I ran across his paper upon this very question of the loss of head through a 24-inch stop-valve; and I think that, more than anything else that I have come upon in the course of my somewhat brief experience, led me to undertake hydraulic experimentation, and for a considerable period it served as my model and my criterion in the work which I undertook. I think both Mr. Kuichling and myself have possibly improved somewhat on the methods which were set forth in that paper, but it gives me pleasure to testify to the fact that he has been, you might say, not exactly a patron saint, but perhaps a guiding star. [Applause.]

This matter of using various devices for meters is quite an interesting one. Almost any device, almost anything, can be used for a meter, from a brickbat to a straight line of pipe. I not long ago designed a line of 12-inch pipe 1,000 feet long, which was laid on a straight grade, with no specials, probably as handsome a piece of pipe laying as you will find anywhere, to be used as a meter. That was a meter in which there was no restriction of flow over that which would occur in the distributing main itself; in other words, that was the main which was to supply the water to a certain section of territory. We had no pressure to lose, nothing to spare, and we devised that to be used as a meter itself, simply by measuring the resistance in the length of it. To that we could apply the registering apparatus of the Venturi meter, if we choose to do so; but as our pressures were quite low I devised one, which would not be

applicable in cases where there was much draft, and which departs quite materially from the device of the Venturi people.

Then you may also use a bend in your pipe as a meter, and it may be made a very delicate one. You may use a gate, you may use a pair of reducers, you may use almost anything that there is in your distribution system which requires a certain amount of head, or any amount of head, to force the water through. But whatever you use, the accuracy of its measurement will depend upon the accuracy of its calibration. You must calibrate that particular thing in the particular condition in which it is to be used. For instance, if you are going to use your gate in a clean pipe 24 feet long with two right angle bends at each end of it, I should very much question the calibration of that gate for a piece of pipe 12 feet long with two right angle bends at the ends of it. I should further question, if you are coming down to a fractional per cent of error, whether you would get the same flow of water with the same height of gate, that is, the same height of the discs above the seat, if the gate reaches that height by being raised, as would be obtained when the gate was being closed. I should expect if you were closing your gate, when it came to that point the discharge through it would be slightly larger than if you were raising the gate to that point.

These are very fine determinations. They are determinations you cannot begin to think of with a pressure gage; you cannot find them at all; there is no use considering them. If you are accustomed to measuring losses of head with an ordinary pressure gage or even a mercury column, you cannot go to that refinement. A water column may hardly show it; you have got to have something much more delicate than that.

These are matters which are very much like the criticism that I was talking of an ideal system here a little while ago. The refinement is too great for the average consumer. He does n't care anything about it. If you want to use a gate for a meter you can do so, but you must make up your mind there is a good big month's work before you first, and the accuracy of the determinations which are made from that gate will depend wholly upon the accuracy of the work you do in calibrating it, and the closeness with which you reproduce in practice the conditions under which it is calibrated.

The little criticism as to the refinement of design, to which I pointed, is of course quite valid. On the other hand, it is a matter

of experience, which has not changed very greatly in a number of years, that the population in a given area will not exceed a given amount under ordinary conditions. That is to say, take cities that may range from 5,000 to 10,000 inhabitants, for example, and we can tell pretty closely what their population will be twenty years from now, or five or ten years from now, unless there should be some exceptional abnormal condition which might affect their development. For instance, the discovery of coal mines, or the discovery of natural wealth of some other sort, may cause an abnormal increase of population. But in the older and steady-going places it is not difficult to determine pretty nearly what the population will be at the end of a given time. And knowing what the population is likely to be you can also determine pretty nearly what the population per block will be; and knowing the number of lots in a block you can determine pretty nearly how many families you will have to supply. So in designing your system it is possible to design it to meet the requirements very closely.

The statements which have been made with regard to the sizes of pipes required for supplying water for fire protection I think are mainly correct. A 6-inch pipe 300 to 500 feet long will give two very good fire streams; we can count on that. If 4-inch pipe is to be used, I would a great deal rather have one stream than two, and would expect better results. There are places where you would not need a hydrant on the line at all. Take a case where your streets are 300 feet apart, you can put your hydrants at street corners; for the cross line is the place where the small pipe comes in.

Of course we are all well aware that this trouble from tubercles is a serious one. In some places I have seen pipes which have been in service twenty years come out as clean as the day they were laid. If they could coat pipes that way twenty years ago, why can't they do it to-day? I have seen other pipes in the same vicinity, the same water passing through them, which have been in only ten years, and when they were taken out you could hardly tell whether they had ever been coated or not. Now I have no doubt it is possible to devise a coating which will be a protection against any water except from the deposit of sediment perhaps. We will have that sediment under some circumstances, but that can be provided for by blowing out. So when we get to the point of the thing it is simply this: that we can design our works with a great deal more accuracy than has been done heretofore, and in these days, when the matter of

water supply is becoming a more accurate science, it is proper that we should avail ourselves of whatever may tend to increase the accuracy and delicacy of our adjustments.

Of course there are a great many of these refinements that it is not worth while to apply in the smaller systems, because the matter of difference of cost, the matter of cleaning out, and all that is so insignificant. But when you come to a system involving 300 or 500 miles of pipe, the matter of keeping it clean and keeping up your pressures in all parts of it is a pretty serious and important question; and in such cases it does pay to get down to the fine point, and you must get down to it if you wish to conduct the system as it ought to be conducted.

There is one point I barely touched on in regard to this matter of resistance through valves. The loss of head through a valve will depend somewhat on its position in the line. If your valve is at the beginning of the line the noticeable loss of head through it will be somewhat less than if it is at the end of the line. That is owing to the fact that the water when it goes through a valve, or through a contraction, gains a head of velocity, and if you immediately discharge the water you lose that head of velocity; it is simply thrown away. But if you carry the water on through a long line of pipe, that head which was temporarily stored in velocity is given back in pressure, and you have it at the end of your line. So when you close a valve in the end of a line you may close it half way and possibly very materially reduce the discharge; but if it is up at the inlet and you close it half way, you may not be able to find the difference at all when you get down to the other end.

The question has been raised as to the matter of introducing small valves in large lines. I think I restricted myself to saying that in large mains it was more economical sometimes to introduce a valve of a smaller size than the main. We all know the difficulty of closing a large valve, that it takes time and skill. When it comes to closing a 36 or a 42 or a 48 inch valve, we all know that unless we have some hydraulic device to help us out it is a pretty slow process, and a good deal of water may get away if there should happen to be a break in one of the mains at the time.

But of course in designing a plant it is often well to balance the possibilities. It is a question of conditions when you get through. There will be some head lost in going through the small valves, although I am not ready to admit that a slight contraction at the

valve, if properly made by reducers before and after, will produce an additional loss of head over that which would be produced by simply the straight pipe. I am not willing to say it will not, but I think it is an open question which it needs some further experimentation to determine; but I myself should have no hesitation in putting in say a 36-inch valve in a 42-inch main, or a 24-inch valve in a 28-inch main. And I think if you put in a dozen of them in a main two miles long it would be a good while before you would know whether those valves were a size smaller or a size larger. But I would not counsel its being done in small street mains. It is n't worth while to bother with it there, for the cost of the reducers would amount to more than the saving in the valves. But when you come to the large ones, where the valves cost a good deal, then the matter of your two reducers is an insignificant item, and it is economical in cost and economical in operation to use the smaller valve.

I was asked to say something upon my heresy. There are some reasons why I do not wish at this time to go into a full discussion of this subject, so I will only take time to point out to you the data upon which the accepted principles of that branch of hydraulics are based. And it is rather surprising to the investigator to find how many things we actually do not know about hydraulics; how many things we are taking for granted upon the basis of experiments which were wholly out of the range of the cases to which we wish to apply them.

Nearly all the recorded experiments which have been made on the subject of the effect of curvature upon loss of head were made more than fifty years ago. The first that we know of were those of the Abbé Bossut, which were published, way back in the eighteenth century. He experimented on pipes having more or less curvature, that is, having a number of curves. I think there is no experiment on record made by him with a single right angle bend in the pipe. The pipes upon which he experimented had diameters very slightly over one inch, not an inch and a quarter.

The next experimenter was Du Buat, and his experiments covered virtually the same ground, except that he did experiment with some pipes which were about two inches in diameter. He experimented with a series of curves one after another in lines, and in his whole series there were only two experiments where the angle of curvature was less than 120 degrees.

The next experimenter on the subject was Venturi. He made

three experiments, one with a pipe 15 inches long and, if I remember correctly, about an inch in diameter, which was straight. He then put an easy curve in it — I believe the radius is not stated — and measured the loss of head in it, and then put a sharp bend in it and measured the loss of head. He found the bend gave more resistance than the curve did, and that they both gave more resistance than a straight pipe.

The next experimenter was Mr. George Rennie, and his results may be found in the transactions of the Royal Society, for 1831, I think. He experimented on a lead pipe one half inch in diameter. The first experiment, I think, was with one semi-circular bend; and then others with a series of bends in the pipe, and also with a series of right angles. He did not experiment with a single right angle bend. He made a number of experiments, and concluded that the subject of curvature was too complex for him to tackle. He simply said that it did n't seem to him that the formulæ of former experimenters were correct. In this connection it may be proper for me to refer to the work of Dr. Thomas Young who, though I believe he made no experiments upon curves himself, deduced from Du Buat's experiments a formula which fitted those experiments much better than Du Buat's own; and while I do not regard it as an ideal one, it was certainly a very ingenious empiric formula. The interesting thing about Dr. Thomas Young is that he was a physician and not an engineer at all, but he investigated the subject in connection with the study of the flow of blood in the human body. And one who will read his discussion of the movement of fluids through tubes must admit that he certainly possessed a very high comprehension of the laws of the flow of water and of other liquids in small pipes. The article in the "Proceedings of the Royal Society" for 1808 is well worth reading by any who are interested in the older history of hydraulics.

There were some experiments upon curvature that are recorded as described in the "Transactions of the Institution of Civil Engineers of Great Britain," along somewhere about 1850. They were made at Liverpool with lead service pipe one half, three quarters, and one inch in diameter. The radius of the curves is not given and the experiments are incomplete, although they show certain effects due to curvature.

The next experiments, and those which are regarded by the scientific world probably as the most useful, were those made by Weis-

bach, the results of which are presented in his "Mechanics of Engineering." And as it is upon those experiments that the most generally accepted formula is based, I have taken pains to go through them carefully and somewhat critically. I found the bulk of Weisbach's experiments were made upon pipes 1 centimeter in diameter; there were some made upon pipes 3 centimeters in diameter. So far as I was able to find, there was also a record of one experiment, I believe, on a pipe about 1½ inches in diameter. Beyond that diameter I found nothing in his works. The experiments were made upon elbows and curves, the radius of curvature in no case, I think, exceeding 3 diameters of the pipe upon which he experimented. They were made uniformly with short outlet pipes, that is, with a short piece attached to the curve. Many of them consisted of first taking a right angle, then adding another right angle and then another, virtually the old plan of compounding the curvature with the idea that three right angle bends ought to give three times the resistance that one did. I may say they do not by any means.

Then the experimenters upon this subject seem to have lain still until about 1886, when a member of this Association made a series of experiments upon fire streams, and incidentally took up the subject first of the effect of sinuosity upon the discharge of a hose, and afterwards experimented upon the curvature. Mr. John R. Freeman was the first one who came upon the law, which I think we may now accept — at least I am entirely willing to accept it myself — that the loss of head due to a bend does not increase as the radius of curvature decreases, until you get down to a pretty low limit. Mr. Freeman found, in short, that he got more resistance when his hose was bent around a curve of 3-foot radius than he did when it was around one of 2½, and more around a 2½ than he did around a 2-foot radius, and also that the resistance was an appreciable amount. Still, if you will look at the text-books, even those which have been published since those experiments, they will tell you that long, easy curves introduce no appreciable resistance. They will go on and say that no engineer would make curves so sharp as to materially retard the flow of water; and they will say that while Weisbach's experiments were not as complete as they might have been, it may be expected that if you do not make your curves sharper than 5 diameters, or perhaps than 4, there will not be much trouble. I have no hesitation in saying here that you will get better results with curves of less than 4 diameters than with a larger radius, and when you get the larger radius the loss of

head becomes a very serious matter. I might give figures, but they would be from memory and might be inaccurate. So we really are indebted to Mr. Freeman for pointing out to us the true law of curve resistance; and although he at that time did not believe this law was continuous to the limits which I have since found, he nevertheless is entitled to credit for being the first to discover this apparent paradox in the science of hydraulics. I think for the present if any of you are worrying over the sharpness of the curvature in your pipes I may simply say you may sleep peacefully, but you will have to take my word for it just now. I have shown you upon what a small foundation the formula given in the text-books rests, and that Mr. Freeman's experiments on a 2½-inch hose were really far nearer the conditions in practice than the experiments of Weisbach or of any of the rest.

I would refer any who are interested in these old experiments to an article by me in "The Technic" for 1899, published at the University of Michigan. The recorded data and results are there given at considerable length.

Mr. Haskell. I would like to ask Mr. Williams if it is not a fact that Mr. Freeman determined this interesting point in hydraulics by actually weighing the water instead of by a computation.

Professor Williams. I cannot answer that.

Mr. Haskell. Without being at all personal, I may say that I asked the question largely on account of my friend Mr. Walker. I know that Mr. Walker has a good deal more confidence in scales than he has in any intricate computation, and I thought perhaps Mr. Williams might answer the question. I could answer it myself, but Mr. Walker sometimes doubts what I tell him. [Laughter.]

Mr. Smith. The coating of pipe is not under discussion here, but I would like to take exception to what Mr. Williams said about not making as good coating to-day as they did twenty years ago. I don't think it is the coating as much as it is the water. Pipes made at the same foundry are put into different places, and from one place they will be taken up after twenty years and be perfectly clean, and in another place a 6-inch pipe will be reduced to 4. It is just the same way with lead pipes. In some places they will last for forty years, and in other places they will fill up in two. I think it is the difference in the water, and not the difference in the coating.

THE CARE OF FIRE HYDRANTS IN WINTER.

BY GEORGE I. BAILEY, SUPERINTENDENT OF WATER WORKS, ALBANY, N. Y.

[*Read September 15, 1899.*]

One principal reason for inaugurating a municipal water supply is the protection it will give from danger and destruction by fire. The fixture that makes the water supply available for this purpose is the hydrant, therefore an important duty of the manager of a water works is the care and maintenance of hydrants, and keeping them constantly in perfect condition for use.

The problem of how best and most economically to secure this good condition is worth consideration, particularly by the members of this Association, whose membership comes almost entirely from cities lying north of the normal line of snowfall and yearly freezing weather.

While the hydrant was originally placed for use at fires, demands are largely made upon it for other purposes, among which are: for filling street-sprinkling wagons; for flushing streets, sewers, and house drains; for a water supply for street improvement work, such as pavements, new sewers, etc. As all these uses of water are legitimate and can be easily so supplied, their use must be accepted; but as the greater the use, the greater the wear, the care of hydrant maintenance is increased by these conditions. To these uses must be added the occasional abuses by malicious, ignorant, or dishonest persons.

In the city of Albany, which has 800 hydrants, the one in greatest use was manufactured by a local foundry, had no modern improvements, and had this especial defect, that the "waste" was always open, even when the hydrant was in service. A separate frost case giving a space of about five inches all around the standpipe was a feature of this hydrant. The method of attending to hydrants in the winter has been the one found in use by the present superintendent when he took office, and which was continued up to a year ago. It was briefly this: In the fall, the space between the stand-

pipe and frost case was filled with sawdust or manure. The city was divided into districts, each district containing about fifty hydrants. At the commencement of freezing weather, extra help was employed and a man assigned to each district. His duty was to examine each hydrant every morning. If the hydrant was found frozen, he was to throw salt in its standpipe and revisit it in the afternoon, and if still found frozen, to report to the office, when the regular employees would take it in charge and thaw it, or make such repairs as might be necessary. Another duty was to clear away or level the snow for ten feet in every direction, to permit a fire engine to get to the hydrant. Directions were given how to examine the hydrant, which included turning it on for trial if necessary.

While this method was cumbersome and expensive, it was believed to be on the side of safety, for the reason that one defective hydrant might result in damage by fire to an amount largely in excess of that paid by the city for all the hydrant inspection. Several successive years, however, showed no diminution in the number of hydrants reported frozen, although all defective ones were put in complete repair or replaced by modern hydrants.

That we might gain a knowledge of the measures taken in other cities, a circular letter was prepared, stating the conditions in Albany, and asking the methods adopted and results secured, and was sent to the water department officials in a number of other cities. A generous and general reply was received. In many instances, not only were the questions answered, but letters giving details of management were received, evidencing an especial interest in the subject. Included with this paper is a summary of the answers received. The methods used varied greatly, but there were certain details common to all, and from these and our own experience, we have revised our method of inspection and care to a more perfect system, and we believe with a decided economy in cost.

We have all heard of frozen hydrants. We all know that hydrants do not freeze, and that the expression means that the water in the hydrant standpipe is frozen and forms an ice seal, preventing the out-flow of water. Water can reach the standpipe from only two sources, either through the valve at the junction with the street main, or through the "waste." If the standpipe remains empty, the hydrant cannot freeze, therefore good drainage for the hydrant standpipe is a necessity for its operation.

In setting hydrants, where possible, the "waste" of the hydrant

TABLE OF DATA RELATING TO CARE AND INSPECTION OF FIRE HYDRANTS IN FIFTY-EIGHT CITIES IN NEW ENGLAND AND NEW YORK.

PLACE.		Number of Hydrants in Use.	Number Frozen Last Year.	What Department inspects and cares for Hydrants.	Are Wastes connected with Street Drains?	When Inspected, and How.
Amsterdam,	N. Y.	275	2	Water	No	Fall inspection, once a week, and after fires.
Auburn,	N. Y.	400	0	Water	No	In fall and repaired.
Binghamton,	N. Y.	670	0	Water	No	Same as Albany.
Brockton,	Mass.	575	0	Water (except snow)	No	In fall, after fires, doubtful three times a week.
Buffalo,	N. Y.	4,600	0	Water	All	3,800 hydrants covered with boxes and straw, others examined every day.
Cambridge,	Mass.	922	8	Fire	A few	Tested in fall.
Corning,	N. Y.	100	0	Water (except snow)	A few	Fall repairs.
Dunkirk,	N. Y.					In fall, after fires, and weekly.
Elmira,	N. Y.	366	3	Water	A few	Fall and frequently in cold weather — four men in all.
Fall River,	Mass.	912	0	Water	A few	Fall repairs and after fires.
Fitchburg,	Mass.	450	10	Water	No	As demanded. By regular employees.
Geneva,	N. Y.	160	0	Water	No	Fall repairs and after fires.
Hartford,	Conn.	769	0	Water and Fire	Most	Fall repairs and after fires.
Herkimer,	N. Y.	73		Water	No	In cold spells — snow packed.
Holyoke,	Mass.	500	2	Water	No	In cold extremes — snow removed.
Hoosick Falls,	N. Y.	90	0	Water	No	Fall inspection, and when necessary.
Hornellsville,	N. Y.	154	0	Water	No	Fall and after fires.
Hudson,	N. Y.	190	0	Water	A few	Fall repairs, after fires — one man.
Jamestown,	N. Y.	200	1	Water	No	Fall repairs and after fires.
Johnstown,	N. Y.	146	2	Water	A few	Once a week and in cold spells.
Kingston,	N. Y.	352	4	Water	Four	Four or five times a year and after fires.
Lansingburgh,	N. Y.	160	2	Water	No	In fall.
Lawrence,	Mass.	564	0	Water	No	Spring and fall.

Lockport,	N. Y.	400	12	Water	Few	Fall repairs — two men when necessary.
Lowell,	Mass.	1,125	0	Water and Fire	No	Spring and fall repairs — one man from Water Works in severe weather.
Medina,	N. Y.	93	1	Water	No	Fall repairs — one man when necessary and after fires.
Middletown,	N. Y.	231	0	Water and Street	No	Two men.
New Bedford,	Mass.	713	0	Water and Fire	No	Spring and fall repairs, after fires.
Newburgh,	N. Y.	400	6	Water	No	Fall repairs, after fires, in severe cold weather.
New Haven,	Conn.	889	2	Fire	No	Fall repairs, and after fires.
Niagara Falls,	N. Y.	128	0	Water	Some	After fires, and once a month.
North Tonawanda,	N. Y.	320	2	Water	No	One man inspects all.
Ogdensburgh,	N. Y.	150	10	Water	Few	Same as Albany — two men do the work.
Olean,	N. Y.	130	0	Water	No	One man.
Oswego,	N. Y.	324	0	Water and Fire	No	Two or three times in winter and after fires.
Owego,	N. Y.	69	0	Water	No	Fall repairs.
Pawtucket,	R. I.	555	0	Fire	No	
Peekskill,	N. Y.	136	0	Water	No	Fall repairs and after fires.
Port Henry,	N. Y.	50	0	Water	No	Fall repairs.
Port Jervis,	N. Y.	150	6	Village and Water	No	Fall repairs.
Potsdam,	N. Y.	100	3	Water	No	Once a week.
Poughkeepsie,	N. Y.	463	1	Water	No	Fall repairs and after fires.
Providence,	R. I.	1,896	12	Fire and Water	No	Spring and fall repairs — Inspection by Fire Department.
Rochester,	N. Y.	2,750	300	Water	Most	Same as Albany.
Rome,	N. Y.	200	3	Water	No	Spring and fall, in cold weather, and after fires.
Salem,	Mass.	448	0	Water	No	After severe cold.
Saratoga Spa,	N. Y.	250	7	Water	All	Fall repairs and occasionally.
Schenectady,	N. Y.	352	0	Water	Half	Fall repairs and once a week after.
Sing Sing,	N. Y.	115	8	Water	No	Daily.
Somerville,	Mass.	836	11	Water	No	Fall repairs, once a month, and in severe cold.
Springfield,	Mass.	940	0	Water	No	Fall repairs, after fires, and two or three times in winter.
Syracuse,	N. Y.	2,481		Water	Yes	Fall and spring and occasionally.
Taunton,	Mass.	756		Water	No	Fall repairs, doubtful hydrants every day, and after fires.
Troy,	N. Y.	762	43	Water	No	Personal inspection.
Utica,	N. Y.	580	1	Fire	Most	Fall repairs, after fires.
Waterbury,	Conn.	325	0	Water	No	Two men do all work, after fires, and severe weather.
Whitehall,	N. Y.	51	1	Water	Most	
Worcester,	Mass.	1,605	0	Water	Yes	Same as Albany, but not every day.

should be directly connected with the street drain, but in many cases hydrants are placed before street drains are laid, and it becomes necessary to make other provisions for waste water. The common method is to fill in the bottom of the pit dug to receive the hydrant with loose stone or coarse gravel to a point above the "waste" opening. The voids in the stone below the "waste" should be sufficient to take more than the full contents of the hydrant standpipe, thus allowing a complete emptying.

Where the hydrant is set in swampy ground, or in ground saturated with water, or in earth of a porous character which after storms becomes saturated, or in clay soil with no sufficient waste receptacle, the ground water will pass into the hydrant through the "waste." In such cases the "waste" must be plugged and the water pumped out by hand, and the pumping repeated after each use in winter.

Several weeks before cold weather examine and test every hydrant carefully. Repair any defect found. Where minor defects are discovered, which would not warrant extensive repairs, note hydrant as doubtful. See that the valve does not leak, that the "waste" is free, and the standpipe empty. Lubricate the hydrant nozzle cap and the valve rod. After inspection and repairs, mark the nozzle cap with paint, which indicates that it has been inspected and shall not be used for other than fire purposes until spring, when the hydrant is to be reinspected and placed in service for other uses, and the paint mark removed. In winter make the inspection through the regular employees of the department. A raw employee will do more damage than good. Confine the examination to the doubtful hydrants and those that have been used since the fall inspection, and examine them every day in freezing weather, and until they have been proven in good condition. Do not allow the hydrant to be opened for trial. Use a metal bob to sound for ice. If found frozen, thaw out with steam and pump the standpipe dry, then throw in a handful of salt. If for any reason it is necessary to open the hydrant, let it run so long that all frost will be thawed from the metal, so that no skim of ice will be formed to clog up the "waste." One or two general examinations of all hydrants during the winter is an added safeguard.

Many methods of thawing hydrants have been tried. We find the most effective method is to have a small portable boiler heated by oil, the whole apparatus not weighing over thirty pounds, and which can be placed in a cutter or hauled easily on a hand sled. Attached

to the boiler is a rubber tube the length of a hydrant, terminating in a metal perforated end, to which is also attached a chain for support. The tube is inserted through the hydrant nozzle into the standpipe, the burner lighted, and in twenty minutes the most obstinate hydrant is completely thawed, and the standpipe is then pumped

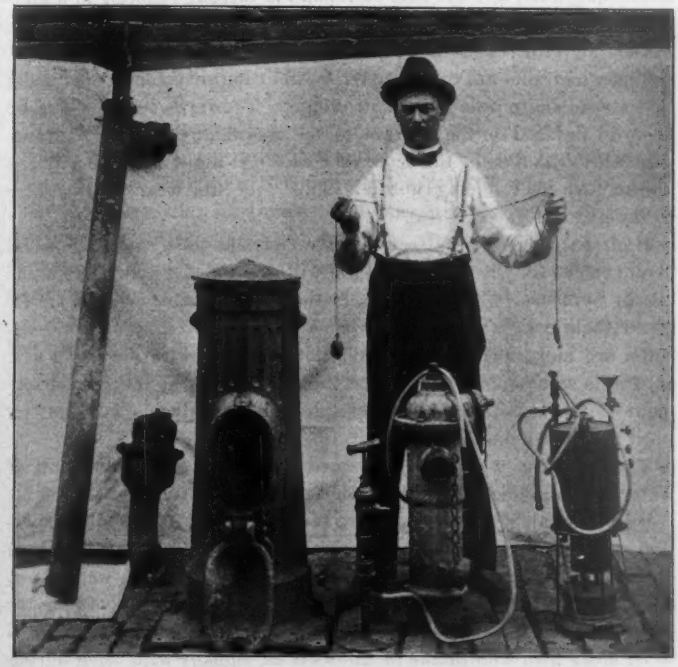


FIG. 1. — APPARATUS FOR TESTING AND THAWING HYDRANTS.

out. The accompanying view (Fig. 1) shows the plumb bob, boiler, and pump used in connection with frozen hydrants.

There are certain conditions of use which should be determined for the protection of hydrants.

Rules should be adopted preventing hydrants used solely for fire purposes from being operated by any person other than persons in the water or fire departments. Exceptions should be made only on

condition that the hydrant be opened and closed by designated water works employees. When this rule is made it should be strictly enforced, even to the extent of arresting and prosecuting all violators.

Select carefully a modern hydrant for your works. Do not change from that hydrant without the best of reasons, for all its parts are interchangeable, and the cost of repairs is thereby reduced to a minimum; also the regular employees become familiar with it, and no outside help for repairs has to be employed.

When hydrants are to be used for street improvement work, insist that a reducing nozzle with controlling cock for street hose be used. Have this placed on the hydrant in the morning, open the hydrant, and control its flow by the separate cock. At night close the hydrant and remove the reducing nozzle. This prevents wear and damage to the hydrant valve.

Hydrants used to fill street sprinklers should have such a special arrangement for the purpose as you will see on the hydrants in the city of Syracuse. They look better than the special sprinkling standpipe; their cost is only one tenth as much; they give as good results, are more available, and do not interfere with fire purposes. Hydrants so equipped are opened three full turns at the commencement of the street-sprinkling season, and the valve is not shut off until the season ends.

The situation was briefly summed up by the superintendent of water works in one of the Massachusetts cities as follows: —

"In general, if the hydrants are found all right at the fall inspection and are in locations where the drainage is good, and are let alone during the winter, they will be all right, because, as you well know, so long as the water is kept out of the standpipe it is impossible for the hydrant to freeze. The worst thing that can be done to them is to let some man who thinks he knows it all monkey with them during the winter to see whether they are all right, and thus make them all wrong."

DISCUSSION.

Mr. Cook. The hydrant service is very important, and the condition of the hydrants causes a superintendent many sleepless nights. I fully agree with Mr. Bailey that no other department than the water department should have the care of the hydrants. I think it should be insisted upon in all cities throughout the country

that the hydrants should not be used except by employees of the water department.

MR. KUICHLING. That the discussion of this paper may not go by default, I would like to call attention to the importance of the matter and to request at least some remarks of assent or dissent from as many as possible present. It is often said that silence gives consent, and I would like to know whether that is the fact in this case. I want to put myself on record here by saying that I agree in every respect with the recommendations of Mr. Bailey, and I hope that others will have the courage of their convictions either for or against what he has said.

PROFESSOR WILLIAMS. I would like to endorse what the last speaker has said. I felt that the author of the paper had presented this matter so thoroughly that there was very little more to be said. I can only say that in Detroit, if I may use the term, they went Albany one better. The fire hydrants were handled by the fire department employees, and the water department employees had to let them alone.

PRESIDENT FORBES. I think I can assure Mr. Kuichling that if we had a rising vote in answer to his suggestion it would be unanimous in favor of Mr. Bailey's recommendations.

STANDPIPES.

BY BYRON I. COOK, SUPERINTENDENT, WOONSOCKET, R. I.

[*Read September 15, 1899.*]

After a careful search through the files of the different engineering journals, I have been able to find but little on the subject of standpipes. I have not been able to ascertain where the first pipe in this country was built and to whom belongs the credit of its design, nor have I found any opinion as to its life. With proper care the yearly depreciation is small. Several pipes in various parts of the country have failed or collapsed; as to the cause of their failure authorities differ. The one at East Providence, R. I., that collapsed a number of years ago lies to-day in the same position as when it fell; and in all the testimony of the several trials at law to place the responsibility for its failure, the cause has never been satisfactorily explained. Poor design and workmanship is without a doubt the cause of a large number of failures. Nearly all the pipes that have failed have been of steel, and I know of no case where deterioration has been the cause of a failure. The percentage of failures is too small when compared with the number in use to warrant any very extended investigation where economy demands their use.

The city of Woonsocket, R. I., has three standpipes with a capacity of 1,978,000 gallons. Nos. 1 and 2 are located within 50 feet of each other, No. 3 about 500 feet to the west of Nos. 1 and 2. The pipes are about three fourths of a mile from the center of city and at an elevation of about 250 feet above it.

Pipe No. 1 was erected in 1884 and is of iron, hammer riveted, 50 feet in diameter and 30 feet high. The thickness of shell is as follows: —

Lowest 5 feet, $\frac{7}{16}$ inch.
Next 5 feet, $\frac{3}{8}$ inch.
Next 10 feet, $\frac{5}{16}$ inch.
Upper 10 feet, $\frac{1}{4}$ inch.

The bottom angle iron is 3½ x 3½ x ⅜ inches, and the top angle iron 3 x 3 x $\frac{5}{16}$ inches. Horizontal seams are single riveted and vertical seams double riveted.

Pipe No. 2 was erected in 1890. It is 50 feet in diameter and 35 feet high, the bottom being 5 feet lower than that of No. 1. This was done to save additional masonry, and as the delivery main deflects quite rapidly from the pipe, the additional 5 feet can be utilized. The bottom plates are ⅜ inch thick and the thickness of the shell is

Lowest 5 feet, ½ inch.
Next 5 feet, $\frac{7}{16}$ inch.
Next 5 feet, ⅜ inch.
Upper 20 feet, $\frac{5}{16}$ inch.

The bottom angle iron is 5 x 5 x ⅝ inches, top angle iron 3½ x 3½ x ⅜ inches. Horizontal seams are single riveted, vertical seams double riveted; vertical seams have ⅞-inch rivets, all other rivets are ¾ inch. This pipe is of iron, hammered and cup riveted. In this kind of riveting the rivet, after being cupped, is finished with three or four blows of a heavy hammer; this flattens the rivet head and firmly seats the rivet. The foundation of this pipe is on ledge. The bed was composed of lime, cement, and sand, the lime being used to prevent the cement from setting too rapidly, but without success. Owing to the large area to be covered and the small amount of space in which to spread the bed, the cement had commenced to set at the center before the pipe was ready to be lowered.

Pipe No. 3 was erected in 1892, and is 76 feet in diameter and 30 feet high. It is of iron and is cup riveted. The bottom plates are ⅜ inch thick, and the shell is made up as follows: —

Lowest 5 feet, $\frac{9}{16}$ inch thick.
Next 5 feet, ½ inch thick.
Next 5 feet, $\frac{7}{16}$ inch thick.
Next 10 feet, ⅜ inch thick.
Upper 5 feet, $\frac{5}{16}$ inch thick.

The bottom angle iron is 5 x 5 x ⅝ inches, top angle iron 4½ x 4½ x ½ inches. Horizontal seams are single riveted, vertical seams triple riveted, all rivets being ¾ inch.

Of the three different kinds of riveting I prefer the hammered cup riveting in pipe No. 2. Fewer loose rivets were found in this pipe and less leakage. This kind of riveting does not leave the

rivet as pleasing to the eye as cup riveting, but for standpipe work I believe it is the best.

The foundation of pipe No. 3 is on ledge, and the bed is composed of sand and coal tar 6 inches in thickness. After the pipe was finished it was found that the bed had been compressed about 2 inches.

The outer portion of the bed was finished with tar concrete pitching at an angle of forty-five degrees from the under edge of the vertical plate. This throws all water away from the pipe and has been most satisfactory.

Every standpipe of large diameter should have a manhole near the outer edge of the bottom for cleaning purposes. A telemeter should be connected with every standpipe, with a recording instrument at pumping station and main office. This instrument is a necessity, as it enables you to compute your consumption at any hour of the twenty-four. You know immediately of an excessive consumption and can locate the trouble quickly. The instrument manufactured by Mr. George E. Winslow, a member of this Association, was installed by the department at Woonsocket at the completion of pipe No. 2; it is simple in construction and does not require the services of an expert electrician to keep it in running order.

With a good foundation, proper design, and good workmanship, the only other important point is to determine what to paint your pipe with, and this is indeed very important. For exterior work I believe the Dixon graphite paint will stand the best. Our pipes have been painted five years with the Dixon paint and are in good condition. For the interior our rule is to paint every two years, and the process is as follows: After water is drawn off the pipe is thoroughly cleaned and then scraped. This is the most expensive part of the maintenance of a standpipe. Your pipe must be clean before applying paint. The simplest and most satisfactory way would be the sand blast; the objection to this is the cost. We use for scraping an old flat file ground to a chisel edge; this, if kept sharp, will do the work nicely. The cost of scraping pipe No. 3 was .092 cents per square yard. For paint I have never had any success with the quick-drying article; the best that I have used is the Durable Metal Coating, manufactured by Edward Smith & Co. For applying the paint I prefer men who are not painters by trade; the novice with a paint brush has not learned the art of covering the most surface with the least paint—

it is just the opposite with him. The cost of applying to the shell two coats and to the bottom one coat was .042 cents per square yard; cost of paint per square yard, .049 cents.

DISCUSSION.

MR. HASKELL. There is one thing in connection with this subject that I would like to hear from gentlemen about, and that is as to the bottom of the standpipe. In order to be sure of good results, the bottom has to be painted at least every two years. Now, it has occurred to me that if a good concrete bottom were put in, the necessity of painting would be obviated, and that it is a practical thing to do. I just throw that out as a suggestion, because I propose to try that with our standpipe, if everybody thinks it is a good thing to do, and possibly I shall if you don't all think so. [Laughter.]

MR. MCKENZIE. May I inquire of Mr. Cook what was the process of spreading the cement under the standpipe, and what was the process of lowering the pipe, although possibly he explained that before I came in. I have had difficulty myself in spreading the cement and from having it set before the pipe could be lowered on to it.

MR. COOK. The No. 3 pipe, which is 76 feet in diameter, was lowered on to a bed of tar and sand, not cement. It was lowered with a common screw jack.

MR. MCKENZIE. What pipe was it which was lowered on to a cement bed?

MR. COOK. The No. 2 and also the No. 1 were lowered on to cement. They are 50 feet in diameter.

MR. BASSETT. In building our standpipes we have had some trouble with the cement running before the pipe was lowered on to the foundation, and we have obviated that by tapping holes in the bottom of the standpipe and pouring the cement in.

MR. COOK. Making it in the form of a grout?

MR. BASSETT. Yes. We build, of course, a dam about the outer circle of the bottom.

MR. COOK. So as to get a head for the grout?

MR. BASSETT. Yes, getting a head of about six or eight feet.

MR. HAWLEY. I think this matter of getting proper joints under a standpipe is of more importance than is sometimes considered.

I had a case a few years ago where a standpipe 15 feet in diameter and 40 feet high, built of wrought iron in 1888, I believe, suddenly developed a leak one night in January. We emptied the pipe and found that one of the bottom sheets had cracked and broken open immediately over the lap of the adjoining sheet. The crack extended for some four or five feet, and we found that under that sheet there never had been any filling. The contractor claimed that the standpipe was lowered on to a bed of cement and sand, but there was no evidence of anything of the sort. There was nothing but the masonry under the sheet. As a matter of fact, we tapped holes through the bottom and poured in something like two barrels, I believe, of cement to fill the voids beneath. The sheet which cracked evidently had worked over the under lap, and the coating of paint, or whatever had been used, had broken there, and the water had attacked the sheet both from above and below, until it had rusted through immediately over this lap. We repaired it temporarily with a rough patch, and afterwards had the sheet cut out and a large patch put in with bolts. I think this shows the necessity of putting in a joint under the bottom of your standpipe so as to leave no voids, and I think that is well accomplished by making a joint with dry sand and cement mixed, leaving the cement to set after the standpipe has been lowered. In that way there is no setting of the cement, and an even bearing can be secured.

Mr. Martin. In South Framingham we built a standpipe in 1896 40 feet by 80, and we made the bed in the way mentioned by the gentleman who has last spoken, with dry cement and sand, mixed, I think, three to one, and lowered the standpipe on to that. So far we have had no trouble from leakage, and I take it for granted everything is all right.

Mr. Haskell. In preparing the foundation for our standpipe in Lynn, after the foundation was thoroughly hardened we put two inches of dry cement distributed as evenly as possible over the entire structure, and lowered the base on to that; and we found it settled about as nearly level as it is possible to have work settle.

Mr. Beals. Mr. President, we have a standpipe system, the dimensions of our standpipe being 20 feet in diameter and 100 feet high, which seems to be different from any which have yet been mentioned. Our method of setting that — the work being done thirteen or fourteen years ago — was to level what was to be the base just as truly as we could, and then we put a coating of sand and

asphalt over it in the same way that the coating for a concrete sidewalk is prepared. We raked it over as evenly as we could and then lowered the bottom courses, before the standpipe was built, into it. I do not know that we ever had any trouble in the fourteen years on account of its settling unevenly, or for any other cause.

In regard to painting, I will say that we have always painted the outside of our standpipe with the best kind of paint and oil we could get; and as we have n't wanted to see a black or red demon standing in our village, we have avoided those colors, and have painted it very near the color of these walls — as near the color of stone as we could get. The inside of the pipe we have always coated with a preparation of the best quality of asphalt, which has been made for us in the town by a manufacturer of varnishes, asphalts, and japans; and, contrary to the suggestion in the paper, we have employed practical painters to do the work. Perhaps we have made an error there, for possibly they might have put it on a little thicker if they had n't been so professional. We have cleaned it in the same way Mr. Cook has mentioned, except that the best instrument for the purpose that we have found is a piece of saw plate inserted in the end of a board, making a big putty knife, as it were. With that we can easily scrape it out very clean, using steel brushes, perhaps, to brush out what that does not scrape off. And we have recoated the inside, as a rule, once in two or three years with this asphalt coating. Whenever we have emptied the standpipe and cleaned it out we have found that the paint on the bottom has stood better than in any other place, being smooth, glossy, and black after the bottom has been brushed and cleaned. What we have put on has always given good service, and I see no reason from my experience to change our practice.

Mr. Cook. I would like to inquire how long ago the pipe was painted inside.

Mr. Beals. I said our rule was to do it once in two years, I think, and that rule is proven, like all other rules, by the exception. I think it is three years now since it was painted. The last time the pipe was emptied, with the exception of a few patches which would scrape off easily enough, there was no sign of rust. These patches would brush off and leave the iron very smooth, with scarcely a pit in it.

Mr. McKenzie. May I inquire of President Cook whether he has been troubled any with ice in the standpipes, or whether the water is so constantly in motion, rising and falling, that the ice does not bother him?

MR. COOK. We have had no trouble from ice at all, that is, nothing to cause any leakage. We have had lots of ice in the pipe, but have never had any serious trouble from it.

MR. BEALS. That suggests to me a question I meant to have asked before. With a standpipe of the size and height of ours there is of course considerable fluctuation in the height of the water. Now you spoke of a telemeter being applied, an apparatus devised by Mr. Winslow. I have studied that thing considerably, and I should like to know how you are going to get your results in the winter, especially where there is danger of freezing.

MR. COOK. I might say that in our case it was far easier to solve the problem than it would be for some. Our telemeter is situated on the No. 2 pipe. Right opposite the ladder I have erected a small cast iron pipe, and that is double boxed. Adjoining that double boxing we have a small building in which we have a stove, and from about the twelfth of December until the first or middle of March we go there once a day and keep up the fire. This place also answers as a storage room for our battery. I think Mr. Bancroft has a telemeter connected with his standpipe in Reading, which is 75 or 100 feet high, and possibly he may tell you how he keeps his float from freezing. I think, however, his is a covered standpipe.

MR. BANCROFT. I have a standpipe which is 100 feet high. We use a telemeter manufactured by the Standard Thermometer Company of Peabody. We use a pressure gage under the standpipe in the pit where the force main goes in, and it gives very fair satisfaction. We have been troubled very much by lightning getting on to our line and burning out the instruments. We have found it almost impossible to get an arrester which would prevent the lightning going across and into the instrument. The line is about three miles in length, giving a good chance for lightning, although the wires are all insulated. We could n't use anything attached to a float at our standpipe. We have an instrument connected with our pump well which works with a float, and that works more satisfactorily than the one with the pressure gage.

MR. COOK. I would like to ask Mr. Bancroft how close registration that gives you on your pressure gage?

MR. BANCROFT. I think there is a movement for every foot on the recording dial at the station. There is no movement on the recording dial unless there is a foot rise or fall of the water in the standpipe.

MR. COOK. As showing the value of a telemeter on the standpipe I will cite a case which occurred with us a week ago. My telemeter registers every three inches' rise or fall in the pipes. I think it was a week ago last Thursday it was rising three inches in about twenty-five to twenty-seven minutes. Along about half-past two I happened to be in the office and discovered that the last registration took somewhere between fifty and sixty minutes. I called the engineer up and asked him if his showed the same thing, and he said it did. I watched it the next hour and found it had increased slightly. I knew then that something was wrong, and inside of half or three quarters of an hour we had located a leak on our force main where it leaves the highway some quarter of a mile — quite a serious leak. Without the telemeter I doubt if it could have been located as quickly, because it would have been impossible to have detected it for some time.

MR. HASKELL. Mr. President, at Lynn we use both methods. In our low service reservoir we determine the height of the water by a float, and in our high service one we have the same device that Mr. Bancroft uses. We have a telltale arranged so that when the water gets to a certain height, within a foot of running over, a bell will commence to ring in the pumping station, so if a man is watching carefully he won't run any water over. We have no trouble with our telemeters; both of them work very nicely. The constant registration of the gage has several times denoted to us leaks that we should not have discovered otherwise until some time had elapsed, because they were remote from where any one would be passing, and we should not have discovered them unless our attention had been called by the drawing down in the reservoir; and with the fluctuation that we often get from day to day in our consumption we would have lost a number of million gallons before we should have detected the leak in any other way than by our gage. And it does seem to me as though the telemeters at the present time work with sufficient accuracy for anybody to feel that they are good things to put in. I think they ought to be put in in all cases. They certainly have been of a great deal of value to us.

MR. BEALS. I would like to ask our friend from Reading if he has had any trouble from having his pressure gage underneath the standpipe, and transmitting from there to wherever his recording dial is; if there is any trouble from frost down there, and also if the registration is close, and when they are pumping, how much the surging of the water affects the record?

MR. BANCROFT. We have n't had any trouble from frost, and no trouble from the surge of the water. The surge is comparatively small, and there being no movement except upon a foot of change, it would n't show on the gage. Our standpipe is 30 feet in diameter, and we thought registration every foot would be close enough. It can be made closer than that if it is desired.

METHODS OF ASSESSMENT AND COLLECTION OF WATER RATES.

BY F. H. CRANDALL, BURLINGTON, VT.

[*Read September 15, 1899.*]

Inasmuch as the object for which municipal water boards in general are striving, the supply to the public of water as nearly "free as air" as is consistent with the cost of delivery, is greatly facilitated by an equitable assessment and impartial enforcement of regulations relative to obtaining remuneration for benefits conferred, this matter of the assessment and collection of rates is of interest.

When the idea that an indirect tax affords the easiest and least felt method of raising funds obtains and the argument that "the water tax comes easy" or that no one complains of the water tax passes current, or when for any other reason the object sought is, instead of low rates, the greatest possible revenue from the water works, that there be equitable assessment and impartial enforcement of regulations is equally desirable.

The first division of this subject to suggest itself is that between the schedule and the meter plan, — between the plan under which it is undertaken to rate the value of benefit received or service rendered by the number and nature of the uses and benefits accorded, regardless of the manner in which they may be used or abused, and that under which it is undertaken to rate the value of benefit received or service rendered, so far as possible, by the amount of the consumption of water.

In view of the fact that the rating by fixtures must, from the nature of the case, be arrived at in total disregard of the principal factor of the cost of their supply, the habit of the consumer, that this plan should afford such generally satisfactory results as it has in the past and now does is quite remarkable. A proposition to settle with one's butcher or grocer on the basis of what Professor "X" estimates to be the amount one ought to eat, plus another amount which the same or some other learned gentleman estimates one is liable to waste, would hardly be regarded as a good business propo-

sition, even in communities where no other method of purchasing water is known.

So long as the supply is abundant and a reasonably satisfactory schedule of rates can be agreed upon, the acquaintance of the water meter need not be cultivated; but when the necessity of such a friend does arise, when the supply abundantly sufficient for legitimate needs proves insufficient to meet also the demand in vogue for waste, or when an equitable schedule rate for various uses cannot be reached, as has been amply demonstrated by general experience presenting numerous object lessons like those furnished at Reading, Richmond, and Atlanta, these brass clerks of the water department will be found capable, efficient, and painstaking servants, more liable to error in favor of than against the consumer.

The principle that risk of any kind has value is universally recognized. In making a low rate for water to consumers who agree to cause no expense by reason of wasteful or careless habits, the water department makes no new departure.

A meter rate, based upon the value of a legitimate consumption, enabling the taker by the exercise of reasonable care and economy, while benefiting the city by the reduction of waste, to secure to himself a corresponding benefit in the reduction of his bill, has in repeated instances resulted in less dissatisfaction over the collection of thousands of meter bills than over the bills recorded by the few dozen meters with which the system was inaugurated.

This condition of affairs is, perhaps, frequently due to the start in the use of meters having been made with rates and regulations under which the greatest mutual benefit was not possible, and to the very gradual acquirement by the general public of the knowledge that with meters, as with figures, apparent misrepresentations do not occur without cause.

That sage remark relative to the inability of figures to lie, together with its corollary, will be found not inapplicable to the case of the automatic machine for measuring water. The greatest benefit which can accrue to the works from the use of meters is freedom from the cost of waste upon metered premises. In proportion as this expense is removed it becomes possible to permit the takers to participate in the benefit. Without the impulse of participation by the takers the greatest benefit to the works appears to be impossible.

The system which permits the economical meter taker to obtain his supply for no less than the schedule rate for such use, and that under

which the works assume not only the expense of the maintenance of the meter system, but also that of leaks on metered premises, are too one-sided to be productive of the best results. The advantage to be derived from the use of meters to be a maximum must be a mutual advantage.

The features rendered conspicuous by the different methods of development of either the schedule or the meter system are numerous and interesting, all having, no doubt, their reasons for existence and their peculiar fitness for the circumstances causing their development. The limited time at our disposal will permit of our taking up of but a few.

The frontage tax, the assessment plan, the sliding meter rate so worded as at various points to offer a premium for waste, and the one so expressed as to cause any increase of consumption to be accompanied by a corresponding increase in cost; the minimum meter rate; the flat meter rate; the charge for the protection afforded by both public and private fire hydrants and pipes; the charge for metered use and waste, both public and private; and the most economical, least productive of friction, and most generally satisfactory method of collecting water rates, are all old and yet eternally recurring questions.

It is a matter of general experience that nothing worth having is without a pecuniary value which must in some way be met, if not by the owner, user, or party benefited, by some one else. The burden thrown upon the shoulders of the ratepayers in general by the failure of an individual or class to return an equivalent for service received, though perhaps when divided among so many an inconsiderable amount for each individual, is like the suit of clothes in the commercial traveler's expense account, there just the same, and with more questionable propriety. It is only when all benefits conferred are assessed upon the benefited at a fair and reasonable rate, with no favored class getting something for nothing, or closely approximating that condition, — of which nature is no more tolerant than of a vacuum, — at the expense of the water department, or in reality at the expense of their less favored fellow citizens, that it is possible to approach the goal, whether it be water as nearly free as is consistent with cost of delivery, or the greatest possible revenue from the water works.

We are all aware that there exist wide differences of opinion in regard to this matter, perhaps not as to the desirability of equitable

assessment of rates and impartial enforcement of regulations, but as to what constitutes equitable assessment and impartial enforcement.

The subject of equitable assessment of water rates, in common with most others, appears different from different points of view, and the diversities of opinion in regard to it may be attributed fully as much to the great variety of conditions under which it is viewed by different people as to the differences of the people themselves.

Self-interest unquestionably exerts no inconsiderable influence on the formation of opinion, and the frequent recurrence and examination of a single phase only of a question has a tendency to warp the judgment and produce one-sided views.

To one employing a large force and using large quantities of water for the philanthropic purpose (most manufacturers are philanthropists) of enabling his employees to earn a living, and incidentally for what there is in it, it naturally seems that the manufacturer should be allowed a particularly low rate. Large amounts accrue to the public treasury from taxes assessed against him and his employees. The local trades people of every class derive a direct and considerable pecuniary benefit from the presence of his plant in the community. The town was made what it is by its manufacturing interests, which cannot be regarded otherwise than as public benefactions entitled at the hands of the town to every possible consideration. It being necessary to maintain water works for other purposes, the furnishing of the additional amount of water required for large consumers necessitates but little, if any, additional expense, and receipts from such sources may be regarded as clear gain.

The cost of 1,000 cubic feet of water pumped, figured from total maintenance, being about $1.00, and figured from pumping station expenses alone about twenty cents, there is an actual profit of about eighty cents per thousand cubic feet on the water sold to large consumers at cost figured from total maintenance.

Inasmuch as the interest, sinking fund, and general management charges are in no wise increased by the furnishing of the additional amount required by unusually large consumers, the large consumers see no reason why they should be asked to pay any part of such expenses.

To the owners of vacant lots the frontage tax or assessment for betterment due to the laying of a water main does not appeal favorably. The party desiring that a water main be laid in the new

street which he is about to open for the purpose of booming the town and increasing its grand list, and incidentally, perhaps, for some other purpose, can see no reason why he should be put to any expense in the matter.

From the point of view of the enthusiastic worker in behalf of some very commendable religious or charitable institution, there is no sense or reason in the public charging for water used by an institution maintained solely for the public good.

The party having a fine lawn to keep up for the public to gaze upon, for which, beside considerable time with a lawn mower, a large quantity of water is requisite, feels that if he is to be charged anything for such use of water it should be but little.

Then there is the party who pays the minimum meter rate, and on finding that he might have used more water for the money, is so impressed by the fact as to forget that he has had all the water he needed, and received at the hands of the water department what he could by no other means secure for the same money, and can see only as he puts it, "that he is being compelled to pay for what he has not had."

And the party, if the sliding meter scale be in vogue, who can see no reason why, inasmuch as the water works belong to the people, and the people in proportion to what they have contribute to the public treasury at the same rate, one taxpayer or stockholder in the water works should be able to get water for any less or be compelled to pay any more than any other taxpayer or stockholder. He does not admit the applicability of the wholesale principle of trade to the case in question and sees equitable assessment only in a flat meter rate. While from his position he can see that the manufacturer made the town, he thinks that he discerns also that the town made the manufacturer, and that it does not require any great sagacity to decide who has made the most. He can see just as much justice in compelling him and the general public to contribute to the expense of maintaining a private lawn, in regard to the maintenance and use of which he has no voice whatever, as he can in requiring that he contribute to the support of a charitable or religious institution in which he takes no interest and in the management of whose affairs he has no voice. In fact, he can see naught but injustice in either, and in the latter a direct contravention of the Constitution of the United States.

In regard to furnishing water to any particular class at a rate

based upon the maintenance of the works by the other takers, it appears to him better that benefactions undertaken at public expense should be made through the appointed channels, so as to be apparent not only to the recipients, but also to the donors, and appreciated by the public at large. He would have the Biblical injunction relative to allowing light to shine obeyed, and not permit its brilliancy and any credit accruing to the town therefrom to be concealed under the bushel of supposedly equitable water rates.

It is contended that individual cleanliness being conducive to the general welfare, means for enabling the same should be furnished free of charge. This is a very pretty theory, and merits a place alongside that, that water should be free as air; but, unfortunately for all theories — and there are many contemplating free water or water at a merely nominal price for certain uses — every quarter furnishes a new demonstration of the fact that the only way to insure reasonable economy in the use of water is by causing it to become a direct pecuniary issue with each individual taker.

There are two ways of accomplishing this, one by means of the measurement and sale of water as other commodities are measured and sold, the other by a system of rigid inspection and penalties impartially imposed, to which latter the average water taker does not take kindly.

Any inspector is well aware of the fact that visions of yards of plastering thrown down and carpets spoiled on account of a leaky fixture and stopped-up drain, of new fixtures rendered necessary on account of long-continued waste, and of large meter bills and fines as the results of a like cause, are his best allies in the never-ceasing strife to keep the consumption within reasonable bounds, and make reasonable economy in the use of water a direct pecuniary issue with the takers.

What inspector has not frequently been told on calling the attention of some most estimable party to the constant flow permitted from a fixture in need of packing, "We pay by the year," or, "I pay too much for water any way, and am not likely to use more than my money's worth." This latter opinion, in towns where from fixtures in public buildings, schools, etc., public servants are allowing water to constantly run to waste, is not unreasonable. If water is not of sufficient value to warrant the prevention of waste in public buildings, the shutting off of public fountains during the night or

during a rainstorm, why should the individual be expected to spend his time, or, worse yet, his money, for the checking of waste?

The evil effect of the toleration of gross carelessness and useless waste of water in public places does not terminate with the waste itself, but is more felt in its encouragement of waste in schedule ratepayers and breeding of dissatisfaction with rates among metered consumers. There is little reason to expect the individual to respect regulations for which the corporation making them by the acts of its officials — and actions speak louder than words — manifests an utter disregard.

To the party who has ignorantly or carelessly permitted a large amount of water to run to waste through a metered service, it is liable to appear that the extra cost of the unusually large amount due to his own negligence or that of his agent over that of an ordinary amount should be borne by some one else than himself. The reasons advanced for permitting the cost of such waste to be borne by the takers in general rather than by the party whose business it was to look after the fixtures on the premises on which it occurred are not numerous, though varied in expression and under certain circumstances quite convincing. That the taker was unfortunate; that he resided out of town; that his tenants were not at all mindful of his interest; that a like leak on the premises of an unmetered taker would have cost the taker nothing; that the leak was not easily located; that it is well to keep on friendly terms with consumers; and that such action, coupled with the warning that it will not be taken a second time, tends to avoid friction at the time, and to prevent a repetition of the cause; are among the number. While perhaps these reasons, in discussion with the negligent party, seem of apparent weight and pertinent to the subject under consideration, at any other time, or in discussion with a party whose degree of wastefulness has not quite reached the proportions deemed worthy of reward, they appear for the most part quite irrelevant.

Policy may sometimes suggest that waste be permitted for purposes of courtesy, to prevent friction, or for some other reason. The legitimacy of such action is, however, bound sooner or later to be called in question, and a rebate made on the ground that a waste of any considerable amount occurred without knowledge or fault of some one, is obviously made without ground. A waste of any considerable amount without the knowledge of the party whose business it is to attend to such matters, or the non-existence of such a party

looks, at the outset, like a grievous fault, which will be none too grievously answered by the payment of the bill.

The party at fault is not apt to criticise the course of reasoning adopted to free him from the natural consequences of his error, and the takers who pay for what they use and waste may, perhaps, be a long time in finding out that the treatment accorded them is not exactly that accorded to some others. When B, C, D, and others do learn that A, because his larger consumption was caused by waste and not by legitimate use, or for some other of the equally good reasons assigned in such cases, has been permitted to receive a rebate, to pay much less than they for a like quantity of water, it is liable to be a difficult matter to convince them that equity or a desire to deal justly had anything to do with the settlement. It may be found that friction, instead of having been avoided, has been transferred, and the heat so intensified as to sweep all explanation and argument before it.

While there is no good reason why the city should be at the expense of making frequent meter inspections for the purpose of preventing waste, there is no means involving so little injustice to those who neither need nor wish assistance in such matters, so well calculated to lessen friction in the collection of meter rates.

Most water works are intended to serve the double purpose of fire protection and water supply, neither of which can be classed as universally the principal cause of the construction of the works. Each may be subdivided into public and private.

The question as to whether private fire services are a sufficient public benefit to warrant the assumption by the public of the expense of maintenance and legitimate supply, beside the risk of their resulting in damage rather than benefit, both to the user and to adjacent property, as well as the risk of their illegitimate use, is not everywhere encountered under such uniform conditions as to warrant its being answered with the uniformity that it is.

The annual cost of public fire protection should be assessed upon those benefited in proportion to the benefit received. To really do this is impossible. By the frontage tax, direct assessment upon real estate, hydrant rental, or direct appropriation from funds raised by general taxation, the end desired is approximated.

The needs of fire protection may frequently and at short notice demand double the regular rate of consumption in all except the

largest cities. To meet them a reserve supply and a capacity for delivery far in excess of ordinary needs are requisite.

The interest on the additional cost of a fire protective works over that of works designed to furnish domestic supply only may be assumed to fairly represent the cost of the protection afforded by the water works. The amount of water used, even at the maximum, constitutes but a small and unimportant part of the total cost.

It is evident that neither the cost of nor the amount paid for fire protection in other places, which latter amount is frequently determined without regard to the former, furnishes information of any value as to what the former is or the latter ought to be in any particular case.

We start out with the idea that the value of the supply of individuals and private corporations for domestic and industrial uses, and the supply of the general public for schools, public buildings, fountains, parks, troughs, street watering and cleaning, flushing sewers, etc., may fairly be based upon the quantity of water consumed, no cubic foot furnished costing more or less than any other cubic foot, but we at once find that a modification is needed. In the first place, the value of the supply is not strictly proportional to the amount of water used, inasmuch as the ability to obtain water under pressure, even in case none or practically none is used, is of value, and in the case of small consumption constitutes so large a proportion of the value of the service as not to be neglectable.

This matter may be equitably adjusted in various ways, none better than by the establishment of a proper minimum rate, which, when applied to meter takers, serves also a good sanitary purpose.

The question also arises as to the propriety of making the prices for water vary, as the prices of many other commodities do, between wholesale and retail customers.

So long as the wholesale purchaser pays for like quantities as those used by the retail purchaser a like price, and the wholesale purchaser receives the favors accorded to that class only in proportion as increased demand shows the wholesale nature of the transaction, there seems to be little ground for complaint of a reasonable recognition of the difference between large and small consumers. The correct solution of this question will vary with the conditions obtaining in different cases; the advantage, however, of so wording the sliding meter scale as not to admit of obtaining an increased quantity of water for a less amount of money is apparent.

The long lists extant of differing schedule prices for delicate variations of use and accompanying waste of water and for different degrees of benefit derived from the presence of water mains attest the general earnest desire to make the assessment of water rates fair and just, and are in themselves monuments of patient and painstaking research necessary to the discovery, not to mention the rating on an assessment roll, of such multifarious uses and benefits.

We might go on indefinitely examining the different aspects of the question of the assessment of rates as viewed from different locations and from amid different surroundings; but from the few mentioned it is apparent that an equitable assessment cannot be arrived at off-hand, that an assessment found pretty generally satisfactory in one case may not prove at all so in another, and that at the best, perfectly equitable and satisfactory assessment can only be approximated.

A public monopoly, having power to refuse to supply water to premises against which bills are outstanding, whose bills are made a lien on the property where they accrue, would seem in view of the means at its command for securing its dues to be in a position to ignore the consideration of methods of collection. The method of assessment having been satisfactorily adjusted, the expenditure of any considerable amount in making collections would seem to be unnecessary.

All water works are not in this position, however, and even in the case of those that are, a very slight knowledge of human nature enables one to perceive that great advantage will accrue from the use of popular methods.

The method of having very rigorous and specific regulations relative to the collection of rates to be used mainly as a bluff, of making the enforcement or non-enforcement of rules a matter of judgment, while perhaps under certain circumstances or for a short time capable of yielding satisfactory results, is not, when generally understood and appreciated, calculated to meet with popular approval.

A light penalty for failure to pay promptly, or a small discount for prompt payment, and the discontinuance of the supply with attendant costs in case of continued delinquency, are generally satisfactory features of most methods of collection.

The reports of numerous cities offering a discount for prompt payment, and granting the discount under no other conditions, that about ninety-five per cent of the ratepayers secure the discount, and

but a fraction of one per cent insist on the discontinuance of the supply; and reports of very much the same tenor from cities impartially enforcing a penalty for failure to pay promptly, leave no room for doubt as to the general satisfaction with such methods.

To one accustomed to the bad debts and items chargeable to profit and loss in private business, it seems remarkable, if not incredible, that such results as are reported can be obtained; that, for instance, of twelve months' bills to the amount of $474,000, at the end of the fiscal year but $68, a very small fraction of one per cent, remains unpaid. By investigation, however, one may learn that the above-cited case is not unique. Like results are wont to obtain where regulations are enforced with like impartiality.

That people are not alike and cannot be treated alike, that circumstances alter cases, and that discretion should be used in everything, no one has a better chance to learn than the water registrar, who is also in a position to appreciate the facts that it is only occasionally, not always, that circumstances alter cases, that the most well-meaning and capable of executive officers is liable, at times, to be unduly influenced by the manner of the presentation of a case, and that a most effective way to minimize such errors and insure uniformity of action in accordance with the ideas of the majority is by the enactment of such regulations, plainly and unequivocally expressed, as it is desired to enforce, and the limitation of the exercise of judgment to matters not covered by regulations.

The characteristic of any method of assessment and collection of water rates receiving the most general approbation in the long run is an impartiality in the performance of duty that, recognizing neither position nor influence, serves every one alike.

DISCUSSION.

MR. WALKER. We have our meter rate in Manchester, and we read the meter and we get pay for what goes through it. If a man's meter bill is $17 or $117, he has got to pay it just the same. We go by the meter, and I don't know any other way to do, if you have a meter, than to go by it. [Laughter.]

MR. KUICHLING. I would like to inquire of Mr. Walker what he does when the meter goes against him. Does he always go by the meter, whether it is right or wrong?

MR. WALKER. Well, when it goes against us in Manchester we take the "next preceding" and reckon by that.

MR. KUICHLING. I was induced to ask that question because of a little case which came up with us where the meter bill of a railroad dropped off some $600 a month.

MR. WALKER. That is quite a drop.

MR. KUICHLING. Yes, a good deal of a drop. The question was, who was to blame, the meter, or the railroad, or somebody else? We found it was the meter which was to blame. It took it into its organization to stop registering, and a month went by before it was discovered. The tactics suggested by Mr. Walker were adopted in dealing with the company, but I have n't heard the result. The company naturally made a protest and said it was a poor rule which did n't work both ways, and how the municipal authorities ever settled the matter I don't quite know. But the ethics of the question are now fairly before us; in a case of the failure of a meter to register properly, what is the right thing to do? I should say in such a case as that you should test your meter thoroughly, and then try to reach some kind of a result on the basis of the preceding period of use when the meter was not under suspicion. I believe that to be the right thing to do; and conversely, if the meter over-registers you should make a reduction to correspond. I know of only one such case where a meter over-registered largely, and that has been a mystery to the manufacturer of the meter and to myself ever since. It slipped the cogs somehow and began to over-register. The consumer demanded a rebate, and he also thought it was a poor rule which did n't work both ways.

MR. SULLIVAN. I was about to ask the same question as the preceding speaker, as to what to do in such cases. In our city, when we have a meter reported as being out of condition, we test it and then put it back, or place one of the same size and get a reading for a month, and then if the meter runs regularly for a month we average the consumption for the last six months and send a bill to the consumer for the amount of water that we suppose he uses. But the other day we had a very peculiar case. A man came into our office and said he thought he was paying for more water than he was using. He brought me in the report of the amount he had paid each month for the last six years. We found on examination and comparison of the books that the amount he paid was very regular, I think it averaged about $50 per month; but for the year 1899

he had paid from January 1 to September 1, in those eight months, about twice as much as he had paid in any one year of the previous six or seven. We made an examination of the meter and found that he had not been paying for water enough in the preceding years, and that for the last six or eight months he was simply paying for the amount of water he was using. We got a report from our inspector last December that he thought the meter was out of order, and we then had it examined and we placed a new meter in operation there. We found that one of the cogs in the old meter was caught and that it did not register properly, and the fact was that it had been working in favor of the consumer, so that for the last six or eight years he had not paid within fifty per cent of what he ought to have paid.

MR. MCKENZIE. The paper discusses in a very lengthy way a great many problems with reference to meter rates and the use of meters, but I don't see that we get a great deal of advice or information out of it as to rates and methods. There was one point I wanted to inquire about, and although the gentleman who read the paper has been obliged to leave, I presume there are those here who are familiar with the practice in regard to the collection of meter rates in connection with fire hydrant rental and automatic sprinklers for fire protection. I have noticed on the cards giving the meter rates through New York that in many cases, where we have ordinarily been collecting $15 or $20 a year for each fire hydrant and perhaps $10 or $15 a year for each 100 sprinkler heads, where you make a meter rate you specify so much for 1,000 gallons or so much for 1,000 cubic feet. In some cases where but little water is used and the water is taken largely for fire protection, the supply for ordinary manufacturing purposes being pumped from the stream, you actually reduce your income very considerably by charging a meter rate; and I would like to ascertain what has been the practice in the matter of charging for fire hydrants and for automatic sprinklers where a meter is inserted and water is paid for by meter rates.

MR. WALKER. Can any one answer the gentleman's question?

MR. SULLIVAN. I will state that in our city we do not charge anything for water used for automatic sprinklers. But I will say in this connection that it is our experience in furnishing large manufacturers, of whom we have a great number in our city, that they often tap the main pipe which goes into the mill for fire purposes and use it in cases of emergency; and we are intending to oblige

every manufacturer who has water service for fire purposes — and the insurance companies of our State require them to have a separate service for fire protection — to put in a meter on the fire service so that we can find out whether or not they are using any water that they are not paying for. But, as I say, they are supposed to get fire service water and their automatic sprinkler service water free.

MR. HAWLEY. In our town we make no charge for water for fire protection where a party lays his own pipe. I was particularly interested in Mr. Crandall's paper, and I had hoped we might be given some information in regard to the assessment of minimum rates, and how they can be collected, whether they can be collected in advance or not. I understand the courts in some of the Western States have made some peculiar decisions in regard to some of these matters, and we have recently made a change in the collection of our rates. When the city bought the plant in 1895, a fine of ten per cent was added to the bills not paid within a certain time. Unfortunately the next year we caught the city solicitor for a pretty good sum, and he immediately decided that the addition of the ten per cent was unconstitutional, and the ordinance was then changed so that all we could do in the case of a delinquent was to shut the water off. Human nature is a good deal the same the world over, and you can only make some men, who won't pay their bills promptly, pay at all in one of two ways: either make them feel it is for their benefit to pay it voluntarily, or else take a club and force them to, and the latter method oftentimes causes a good deal of friction and trouble.

During the past year, under the advice of another city solicitor, a new one, we have reëstablished the fine, with the result that we have collected a much larger percentage of the bills than formerly within the prescribed time, and with much less trouble and friction. A number of legal lights in the town claim we have no right to charge a percentage on a minimum rate which is paid in advance. I don't know whether we have or not, but it certainly facilitates the collection of the bills, and I had hoped that this paper might touch upon that point. Perhaps, however, some of the gentlemen present can enlighten me on the subject.

There is one method of collecting meter rates that has not yet been mentioned, that seems to me is capable of more general application than any other, and that is by making a charge for the first 1,000 gallons or 1,000 cubic feet sufficient to cover the

cost of installing the meter, making repairs, reading it, and keeping the accounts, and then a flat rate for the balance of the water supplied. That applies to a certain extent the principle of the difference between a wholesale and retail business, and it seems to be a fairer way than making a sliding schedule by which there is a chance to obtain more water for a less price. If there is any gentleman who can give any light with regard to collecting minimum rates in advance, I should be obliged for the information.

MR. HAZEN. I have been figuring some time on this matter of meter rates, and there is one improvement as it appears to me on the method which has just been suggested of charging a certain price for the first 1,000 gallons and a flat rate for all water in addition. The improvement is a very simple one. It consists in making a charge for each service, and a charge for all water used in addition always at the same rate. For instance, you make a charge of $3 a year for each service whether any water is used or not, and in addition you charge ten cents per 1,000 gallons, or whatever the rate may be, for all the water that is used. I believe that is a very fair way, easily computed and convenient. The amount to be charged per tap and the amount per 1,000 gallons of course require to be fixed in each case and depend upon a good many conditions. Milwaukee is the only American city which has adopted this scheme, so far as I remember. It was adopted in Berlin last April, after a very thorough discussion of the subject and after a large number of meter rates had been suggested.

MR. SULLIVAN. I would like to ask the last speaker if he considers that a person using a greater amount of water should pay as much proportionally as a person using a less amount?

MR. HAZEN. That is a matter of policy. On the plan which I suggest, if a person uses at the meter rate $3 worth of water per annum, and the tap charge was $3, he would pay only $6, which is twice as much in proportion for the water as a large consumer. For other quantities of water the proportions would be different. A small consumer pays more relatively than a large consumer, and I think that is right, and I think the method suggested is a convenient one for getting at it.

MR. THOMAS, of Hingham. I was talking with a gentleman from New York last evening on this matter of meter charges, and it seemed to me he covered this point exactly. He said they charged so much for the first 10,000 gallons, say 20 cents a thousand; for

the second 10,000, 18 cents; and for the third 10,000, 16 cents, or whatever the price might be. Thus each consumer pays the same for the same amount of water. The domestic consumer pays the same as the manufacturer for a certain amount of water, 10,000 gallons, perhaps, a year, or whatever the amount may be. Then if the manufacturer uses more water he gets it cheaper, but for the same amount of water that the domestic consumer uses he pays the same. It seemed to me that was a very fair way.

MR. SULLIVAN. I would say, Mr. President, that that is our method. We charge so much for meter rental, a per cent on the cost of it, and we charge fifteen cents per 1,000 gallons for the first 10,000 gallons, and for the second 10,000 gallons we charge at the rate of ten cents, and for all over 20,000 gallons we charge at the rate of five cents, which gives the larger consumer the advantage in getting a lower rate for all the water over 20,000 gallons he consumes during the month.

MR. RUSSELL. We have in Ilion just that system. It occurs to me that the whole meter question is very largely one of expediency and policy in the different localities. What might be a good policy in the city of Syracuse might be a very poor policy in the village of Ilion, where I live. And as to fire protection, our policy is to encourage the manufacturers. When we put in our mains we said to the manufacturers: "We will carry a cast iron branch to the curb, and you can extend it into your works and put on as many fire hydrants to be used exclusively for fire purposes as you choose. We don't want your factory to burn up. Put in your automatic system, too; it will cost you nothing for the water, and it will cost us simply the filling of it if you have no fire." Then comes in, of course, the moral question, Can we trust these men to be in connection with our water works, unless we put on a meter which is supposed never to register except in case of a fire? If you have perfect confidence in the manufacturers you don't care to put meters on; but if there is a large number of manufacturers, and among them some that you feel you cannot trust, then the question comes up in that locality.

MR. WHITNEY. Did I understand Mr. Hawley to say that he makes no annual charge for the meters he sets?

MR. HAWLEY. I make no charge for them.

MR. WHITNEY. I think in a large majority of cases where the city owns the meters a charge is made of at least enough to cover the estimated cost of maintenance and possibly renewal of the meters

at some time. That charge, I think, is generally figured at about ten per cent. A great many places charge that, and I think they can hardly afford to do it for less than that.

MR. HAWLEY. That question has come up several times. Our council insists that we shall sell water at a flat rate. "The poor man must be served at the same rate the rich man is" is the argument. It was necessary to stop the waste in certain places, and so we put in meters without charge wherever we thought we could stop it. And then there comes up the question of the cost of providing water for a large consumer, for instance, one using, we will say, a million gallons. We have only in his case one meter to maintain and one account to keep, while for a million gallons sold to a hundred small consumers we will have a hundred times the work to do in making repairs, reading the meters, and keeping the accounts. I think if that is all included in the cost of the first 1,000 gallons, and then a flat rate charged for additional water, it will put the thing on an equitable basis, and we will be paid not only for the water, but for the expense of maintaining the meter and keeping the account.

MR. MCKENZIE. If my memory serves me correctly, this matter of flat rates or uniform meter rates for water was discussed at the meeting of the American Water Works Association, and it was stated by a superintendent, I think from Youngstown, Ohio, that they had established a meter rate on a sliding scale, so that the Pennsylvania Railroad Company, which took a large amount of water, got a rate approximating five cents per 1,000 gallons, while the ordinary rate for householders was twenty-five cents per 1,000 gallons; and that some of the householders had appealed the matter of the collection of these rates and the court has decided that the water department could not collect more from one than from another consumer, but that they must make a uniform rate and that the uniform rate must be the minimum rate. Now that matter may possibly come up in connection with some works with which I am connected. For instance, we sell water at eight cents per 1,000 gallons to large manufacturers, and we have a rate of twenty-five cents per 1,000 gallons for householders. One very wealthy man in town wants to take the water and is going to put in a meter, and he says that he shall not pay any more than other people pay, that his money is just as good as anybody's, and if other people get the water for eight cents per 1,000 gallons he won't pay any more. Now of course we might go to an attorney and pay a large amount of money for an

opinion as to whether we can adopt a sliding scale with a high rate for one and a low rate for another and collect, but I thought there might be somebody here who had had similar experience or who might know of any legal decisions in that line.

MR. WALKER. My experience is that you can't look after your meters short of $15 a year. We do it for $12, but it does n't pay us. Nobody can put in a lot of meters and go to them and read them once a month for $12 a year, but that is our minimum rate; we have that or nothing, and it is just the same whether they use a large amount or a small amount of water. If there is anything which makes tribulation it is a meter. [Laughter.] There is nothing that will kick like a man who thinks he is going to save two or three dollars by having a meter put on and then finds that his first bill amounts to as much as he has been paying in a year. I have seen them when I thought they would go through the roof. [Laughter.] I tell you what it is, we have the most trouble with those folks who insist upon having a meter. They say they don't use much water, and they can just as well save $3 a year as to let the city have it; so we put on the meter and the first quarter perhaps the bill is $8, and then if there is n't a hot time in the old town I hope to die. [Laughter.]

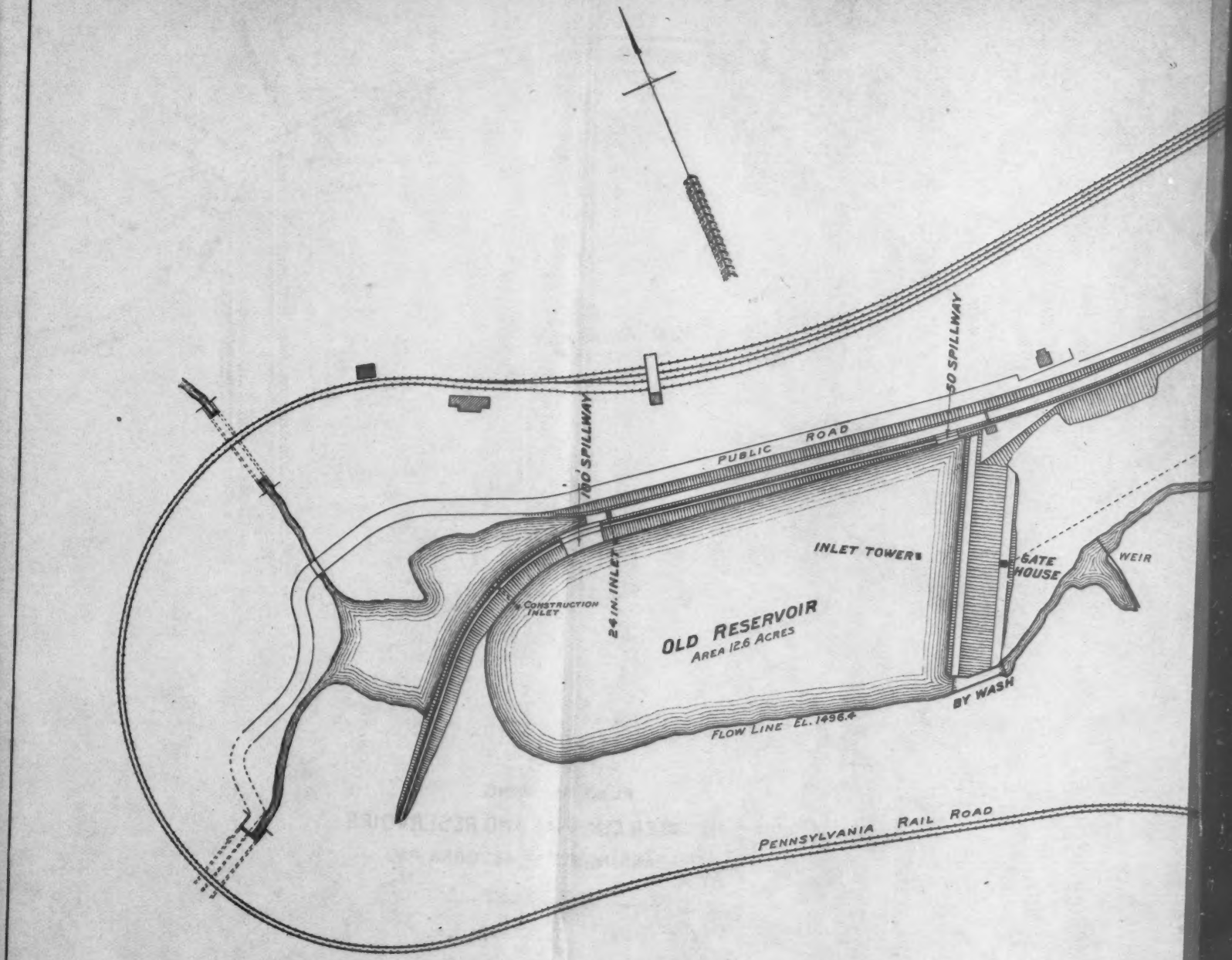
MR. BANCROFT. In our town we make a minimum charge of $6 a year, and that gives the consumer about 16,000 gallons of water. For the next 100,000 gallons he pays thirty cents a thousand; for the next 200,000 gallons he pays twenty-five cents a thousand; and the price for all he uses in excess of that amount is twenty cents a thousand. Our minimum rate is collected semi-annually, $3 each six months in advance.

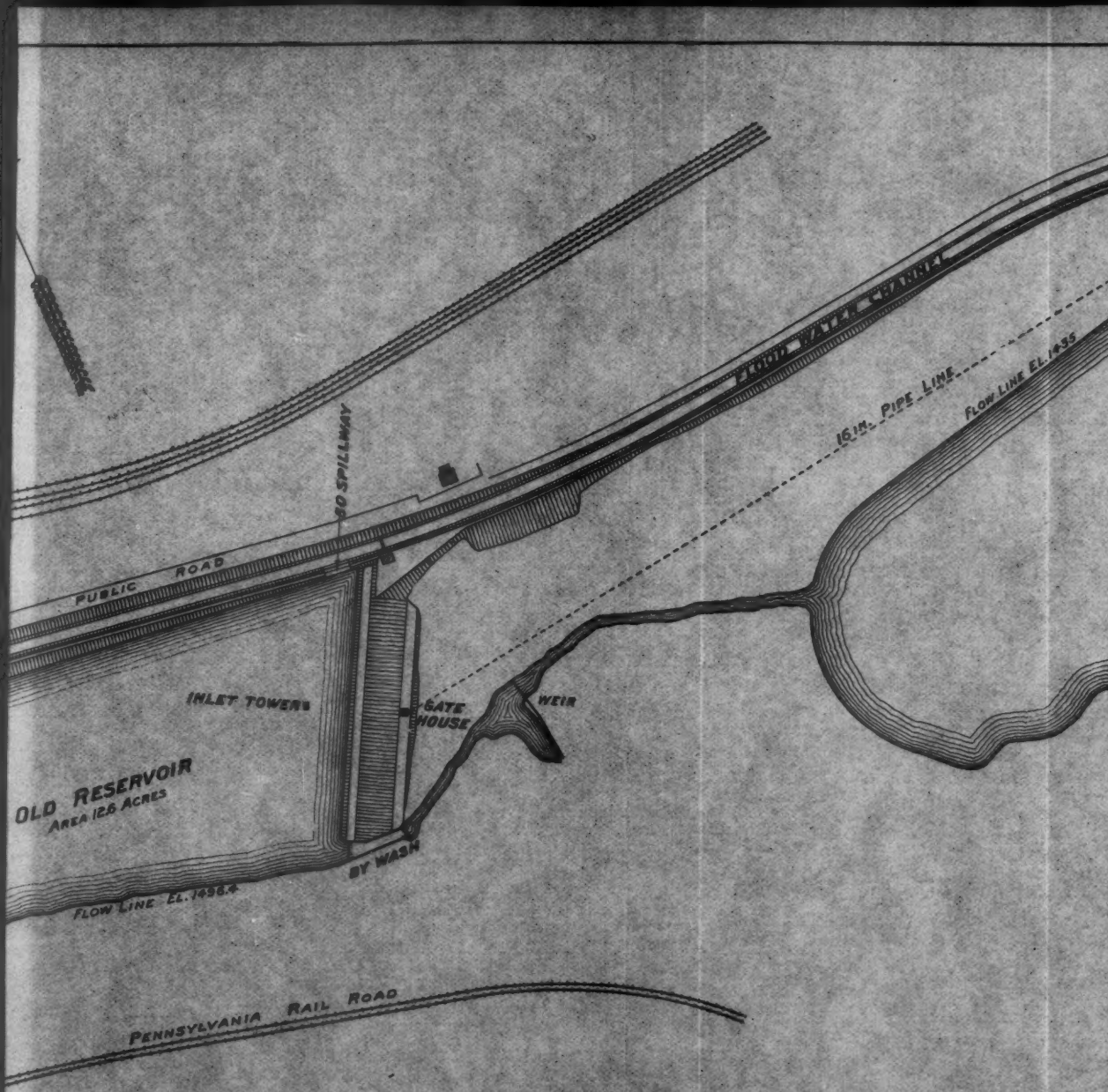
MR. WHITNEY. In reference to the matter of which Mr. McKenzie spoke, there is no question but what under Massachusetts laws he would have a perfect right to establish such rates as he saw fit. Under Connecticut laws I should think it depended altogether on the wording of the charter of the particular private company to which he refers.

MR. MCKENZIE. The charter simply says the directors may establish "reasonable rates." [Laughter.]

MR. WHITNEY. I suppose that one little word "reasonable" makes all the trouble.

MR. MCKENZIE. Nearly all our water works charters are worded in that way.


100' SPILLWAY
50 SPILLWAY
PUBLIC ROAD
INLET TOWER
GATE HOUSE
WEIR
24 IN. INLET
CONSTRUCTION INLET
OLD RESERVOIR
AREA 12.6 ACRES
BY WASH
FLOW LINE EL. 1496.4
PENNSYLVANIA RAIL ROAD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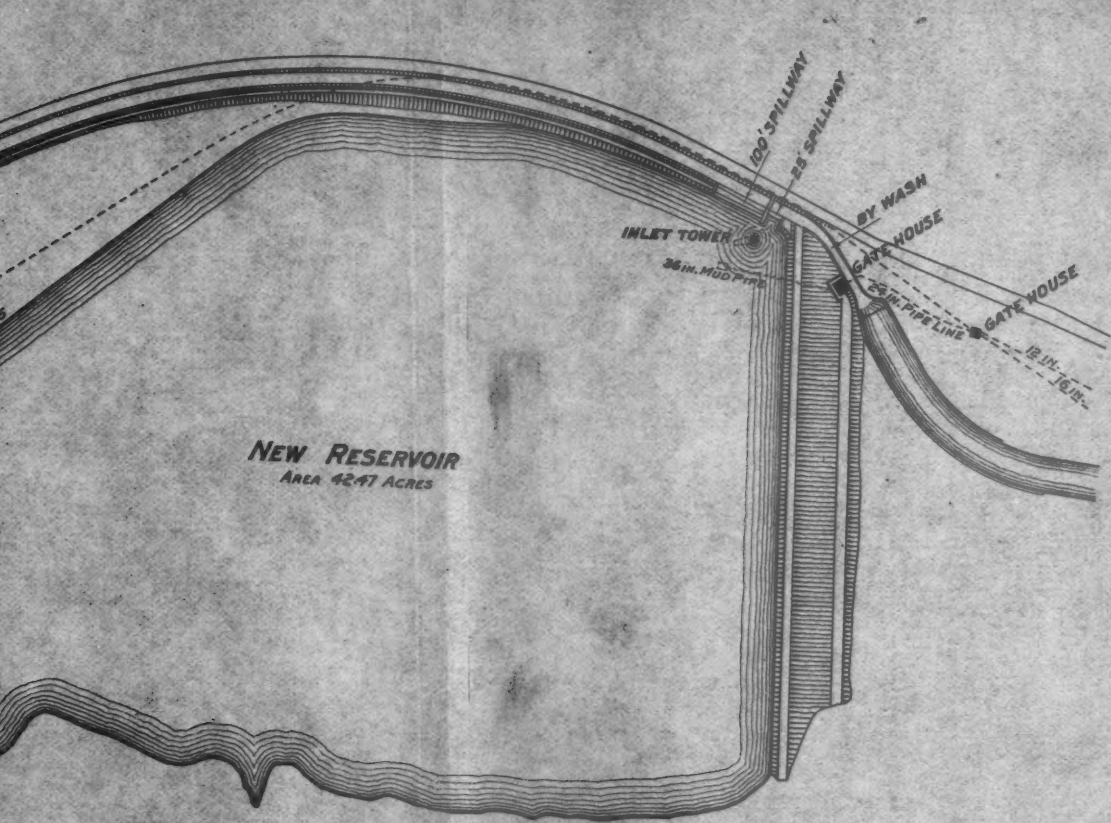


PLAN SHOWING

FLOOD WATER CHANNEL AND RESERVOIRS

AT KITTANNING POINT, ALTOONA, PA.

0 100' 200' 300' 400' 500'

FLOOD-WATER CHANNEL OF THE ALTOONA, PA., RESERVOIRS.

BY CHARLES W. KNIGHT, C.E.

[*Read September 13, 1899.*]

The Altoona, Pa., storage reservoirs are located on Burgoons' Run, six miles west of the city, near Kittanning Point station on the main line of the Pennsylvania railroad. Burgoons' Run is made up at this point of two streams coming down the eastern slope of the Allegheny Mountains. Just below the fork is the upper basin and 3,000 feet beyond is the embankment of the lower reservoir. The flow-line of the upper basin is 1,496.4 feet above tide water, with an area of water surface of 12.6 acres and a capacity of 65,000,000 gallons; and the flow-line of the lower basin is 1,435 feet above tide water, with an area of 36.47 acres and a capacity of 356,000,000 gallons. The distributing system of Altoona is divided into a high and a low service, and these reservoirs are used separately for the two services. The low service is fed through a distributing reservoir within the city, while the high is at present fed directly from the Kittanning Point basin.

The upper reservoir was built in 1887 and the lower in 1894, 1895, and 1896. The flood-water channel was completed in 1897. Previous to the completion of this channel the city had expended about $20,000 in removing some of the more objectionable accumulations brought down the valleys by the floods and deposited in the upper basin. The material washed down consisted of driftwood, sawdust, coke cinder, sand, and gravel. To prevent this reservoir from becoming practically useless in the near future the flood-water channel became a necessity. The amount of material washed into this reservoir had exceeded 20,000 cubic yards in one day; and the flood-water channel was built for the purpose of keeping out this, as well as water heavily charged with sand, soil, and a great amount of vegetable matter that came down the mountain slopes during severe storms, reducing the storage capacity each year by a considerable percentage, as well as impairing the quality of the water.

FIG. 1. — GENERAL VIEW OF RESERVOIRS AND FLOOD-WATER CHANNEL, ALTOONA, PA.

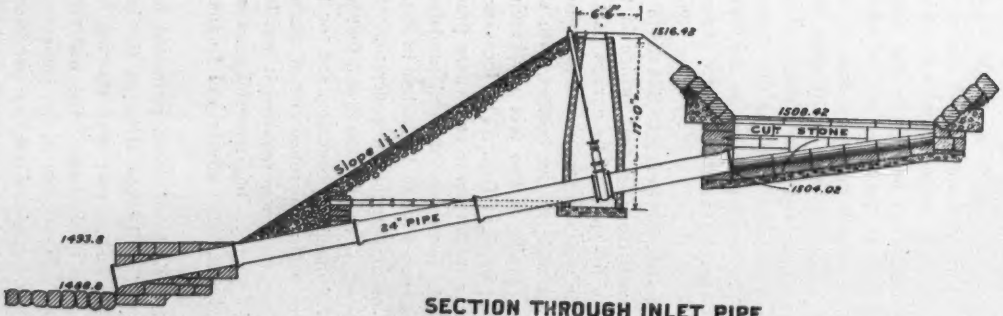
The flood-water channel proper is 3,991 feet in length, but the necessary constructions to turn the water into it above the upper reservoir and return it again to the creek channel below the lower reservoir make the total length 5,630 feet. There is first a diverting embankment 877 feet long across the valley just above the upper reservoir; then comes the main channel, at the lower end of which is the by-wash channel 259 feet long, where the water falls to the level of the valley below the lower reservoir; and finally there is a walled, curved channel 503 feet long, in which the velocity of the current is reduced, and which turns the stream into the old channel in its normal condition. A plan of the work is shown on the folded plate, and a general view of the reservoirs and flood-water channel in Fig. 1.

The walled channel is 60 feet in width, increasing to this width on the apron at the foot of the by-wash from 16 feet, which is the width of the straight portion of the by-wash. The curved part of the by-wash is gradually increased in width to 20 feet at the bottom. The flood channel proper is 20 feet wide at the bottom, with side slopes of one to one and a bottom grade of two feet per hundred for its entire length, and its depth is eight feet. The location of the channel was so chosen as to have its bottom in cut where practicable. All of the masonry of this work was of local sandstone. The bottom of the channel is of dressed stone 15 inches in depth, with ¼-inch joints, on a foundation of 6 inches of concrete. (See Figs. 3 and 4.) The side slopes are paved for the first 3 feet with rock-faced ashlar on a backing of 6 inches of concrete, and for two feet more with a close jointed dry wall; the remainder of the side slopes are in earth. When embankment was required it was built up in 6-inch layers wetted and well rolled. The material excavated was mostly clay and compact sand with small stones and fragments of rock imbedded in it.

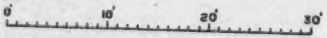
The diverting embankment is entirely of earth protected by a slope wall on its up-stream face and by broken stone on the lower slope. Under this embankment is a puddle core wall starting from an impervious stratum and carried up to its base. The material in this embankment was placed in the same way as on the embankment of the flood channel, and its top has a grade of one foot per hundred for the entire length from the head of the flood-water channel.

At the highest part of this diverting embankment near the old creek bed were placed two lines of 30-inch cast iron pipe with

FIG. 1.—GENERAL VIEW OF RESERVOIRS AND FLOOD-WATER CHANNEL, ALTOONA, PA.



SECTION THROUGH INLET PIPE



SECTION OF FLOOD WATER CHANNEL

FIGS. 2 AND 3.

masonry inlet for passing the stream during the construction of the embankment; and at the point where the embankment joins the flood-water channel proper, forming the throat of the channel, is an emergency spillway 100 feet in length, built of heavy blocks of stone laid dry, with its top or overfall 6 feet above the bottom of the flood channel (Fig. 5).

At its head and extending entirely across the flood-water channel is a sunken masonry chamber with segmental bottom inclined towards the reservoir, having its outlet through a 24-inch cast iron pipe leading down into the upper reservoir and controlled by a valve.

FIG. 4. — FLOOD-WATER CHANNEL.

This chamber is 2½ feet wide and is covered with a heavy iron grating. This structure forms the inlet for all the water let into the reservoirs, as the supply for the lower basin passes first through the upper reservoir (Figs. 2 and 5).

Where the flood-water channel passes the lower end of the upper reservoir is another emergency spillway 50 feet long, with its overfall 1.3 feet higher than the regular spillway of this reservoir and 5.5 feet above the bottom of the flood channel.

FIG. 5. — EMERGENCY SPILLWAY AT THROAT OF FLOOD-WATER CHANNEL, AND INLET TO UPPER RESERVOIR.

FIG. 6. — INLET TOWER AND SPILLWAY, LOWER RESERVOIR.

Adjoining the spillway of the lower basin (Fig. 6), which is 25 feet long and built entirely of masonry, is a third emergency spillway 100 feet in length, with its overfall one foot above that of the regular spillway (Fig. 7). All of these emergency spillways are earth embankments faced with dry walls on the reservoir side, with rubble masonry on concrete backings on the channel side, and with their top paving laid in clay puddle and the cracks filled with fine sand and screenings from the stone crusher.

Fig. 8 is a view of the dam of the lower reservoir, a cross section

FIG. 7. — EMERGENCY SPILLWAY, LOWER RESERVOIR.

of which is shown in Fig. 9. Fig. 10 is a view of the by-wash channel.

Whenever the mountain water is turbid the valve on the pipe at the head of the flood channel is closed. Except after a few storms following long dry spells in the summer this turbidity does not occur unless the rate of flow exceeds 50,000,000 gallons per day, or after heavy floods; when the flow is again reduced to such an amount that the stream becomes clear, the valve is opened. The inlet to the upper reservoir from the head of the flood channel and the regular spillway of the lower reservoir were designed to pass 50,000,000

gallons per day before any water would pass down the flood-water channel or over the emergency spillway of the lower reservoir.

The construction of the three emergency spillways was due mainly to observation of the action of Burgoons' Run and the possibility of temporary clogging of the throat of the flood-water channel rather than to computations from the greatest rainfalls.

At the time of a flood in May, 1894, the water flowed over the top of the embankment of the upper reservoir for about fifteen minutes, on account of the sudden release of large volumes of water

FIG. 8.—GENERAL VIEW OF DAM, LOWER RESERVOIR, ALTOONA, PA.

which had been temporarily dammed at the railroad culverts about 1,000 feet above this reservoir. Although previous to this greater rainfalls had occurred, yet the one of 1894 caused the highest water in the reservoir.

Similar action had been noticed in former years, as on several occasions great flood waves had been observed rolling down the valley and into the reservoir, causing its surface to rise 2 or 3 feet in a few minutes and as quickly subside. What is generally known

as the horseshoe curve of the Pennsylvania railroad lies across the valleys of the two streams which unite in the upper reservoir on an embankment about 100 feet high, through which the streams pass in arched culverts of 20-feet span. The one that was dammed in 1894 is double, having a waterway 40 feet in width. The water rose to a dangerous height before the flood dam gave way, causing the wave that overtopped the reservoir embankment.

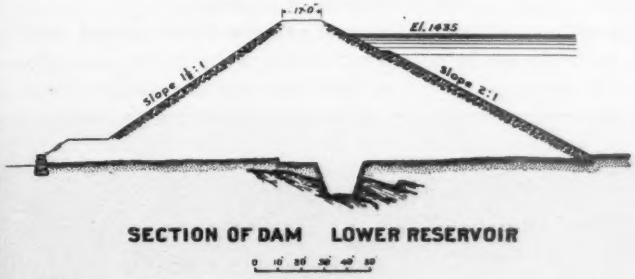


FIG. 9.

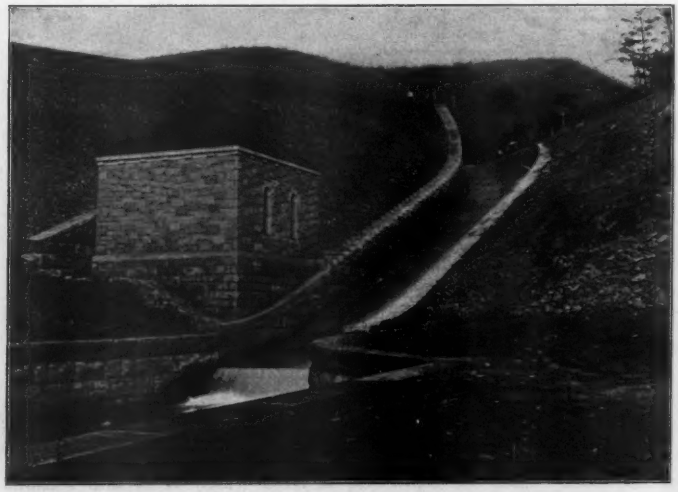
Almost the entire watershed of the streams above the reservoirs is covered with a second growth of trees, while on the mountain slopes and along the valleys lie millions of feet of old logs and trees, great and small, in various conditions of decay, which are gradually sliding down into the stream channel and then more rapidly passing down stream during high water, causing numerous dams, several of which may sometime give way simultaneously and cause large flood waves with ordinary precipitation.

The watershed above these reservoirs has an area of 9.6 square miles, mostly steep mountain slopes, from which at certain seasons at least two thirds of the precipitation will flow off within 24 hours after a storm. The heaviest rainfall known in that vicinity has been about 8 inches in 24 hours on an adjoining watershed, which might mean a constant flow for that time of about 1,500 cubic feet per second. This was during the great flood of 1889; but the flood of 1894, when there was only about 5 inches of rainfall in two days, as recorded, produced a flood volume of about 3,000 cubic feet per second for about 15 minutes, when the upper reservoir embankment was overtopped by the breaking away of flood dams as before mentioned. While such a flood wave may never again be produced,

especially as the Water Commissioners of the city of Altoona are gradually burning the old logs along the creek channels, yet it seemed reasonable to provide a capacity of flood channel equal to the greatest observed volume with a factor of safety against momentary choking at its throat; hence also the construction of the emergency spillways.

In such constructions there are questions that are secondary in importance only to those already considered, such as durability of such a channel and its permanency of operation.

It will be observed that in heavy storms with a normal flow, the



FIG, 10. — BY-WASH CHANNEL, AND GATE HOUSE OF LOWER RESERVOIR.

velocity of the current in the channel will average about 22 feet per second, and at the time of some of the flood waves it may reach 27 feet per second. At such times large quantities of sand, gravel, and large stones are being carried down the valley, and must either lodge in the basin formed by the diverting embankment or pass through the channel. The former will be the case until such a grade has been formed that the force of the water in the greater floods will

carry practically everything that may be washed down the valley into the mouth of the flood channel, where it will be quickly conveyed to the creek below the lower reservoir.

Although the grade of the creek channels up the valleys exceeds 3 feet per hundred, yet on account of the irregularities of their channels and the lesser volumes of water flowing, they do not appear to possess more transporting power than a grade of about one foot per hundred with the double volume of water after the streams unite.

While this fact may be said to be proved to some extent by actual experiments, yet the grade adopted for the top of the diverting embankment was more or less empirical, as it was the result of local observation on the disposition of the material washed down from the valleys. Although a one per cent grade was considered ample to keep it from being overtopped by accumulations in the basin above it, yet its alignment was so arranged as to admit of the slope being made greater, if this ever became necessary, without reconstruction.

The flood-water channel with all its accessories cost about $90,000, or about $16 per lineal foot, by contract at generally fair prices, and the result has been a decided improvement in the taste and appearance of the water, if not in its sanitary condition, and the full storage capacities of the basins will be maintained.

Questions of economy of construction and most perfect operation controlled in the adoption of a uniform section for the flood channel proper, and when the elevation and position of the embankment of the lower basin was known the grade became practically fixed. While a much less grade would have kept the channel free from all accumulations, yet good reason for the plan adopted is readily found when it is considered that the velocity of water cannot be materially accelerated or retarded in such constructions without increased cost. Configuration of the ground may make such a rule inapplicable in some situations; it, however, deserves serious consideration before setting it aside.

It is hardly necessary to remark that storage reservoirs for domestic water supplies constructed in mountain ravines where the wash is considerable should have a flood-water channel of sufficient capacity to exclude the entire flood volume, and that the carrying capacity should be based rather upon observed flood volumes than upon records of maximum precipitation.

To determine even approximately the probable flood volumes from

a watershed, observations of maximum precipitation are not likely to be applicable unless made over the territory under consideration. This will be better understood when we consider that the rainfall on May 30 and 31, 1889, which was considered a general storm, near the city of Altoona on the eastern slope of the Allegheny Mountains, in a distance of less than 10 miles varied between 2 and 6 inches, and within a distance of less than 20 miles, passing over the mountains, it ranged between 2 and more than 8 inches in 24 hours. These observations apply particularly to small and mountainous watersheds.

This flood-water channel and the storage basins protected by it were designed by and constructed under the supervision of the engineers comprising the Stanwix Engineering Co.

COMPARISON BETWEEN HIGH AND LOW DUTY PUMPING ENGINES ON A SMALL WATER WORKS PLANT.

BY JOHN E. SMITH, SUPERINTENDENT, ANDOVER, MASS.

(*Read December 14, 1898.*)

Mr. President and Members of the New England Water Works Association:

GENTLEMEN, — Being known to many of you as a crank on the rotative type of high duty pumping engine for water works service, I wish to assure you that I am not going to tire you with any pet hobby; the few facts which I wish to present are abstracted from reports made to the Andover Water Commissioners covering the years 1895, 1896, and 1897.

As conditions to be met constitute a vital element in any problem, a brief description of the Andover Water Works system will better enable you to judge whether the improvements made in the pumping plant at Andover will prove of equal value in other places.

Haggett's Pond, the source of supply, is at an elevation of 104 feet above mean high water, and five miles distant and on the opposite side of the town from the distributing reservoir. The elevation of the water in this reservoir when full is 309 feet, giving a static head at the pond of 205 feet. The force main is a 12-inch cast iron pipe, which is also the backbone of the distributing system, so that with the pumps running, the system is supplied directly, the surplus pumpage overflowing into the reservoir.

This force main crosses the valley of the Shawsheen River at an elevation of 35 feet, or 69 feet below pond level; there are three summits between the pond and the town, the highest being at an elevation of 168 feet, or 64 feet above pond level.

With the pumps running at their normal capacity, the velocity of the water in this force main is 3½ feet per second and the frictional loss of head is about 125 feet. Thus it is evident that the element of safety of the pumping plant is equally important with that of economy. It requires no argument to show that any considerable

draft of water in the Shawsheen valley, 69 feet below the pond level, will cause a very considerable drop in the pressure from the dynamic head of 330 feet under which the pumps are running. A direct acting pump (unless throttled) can only be adjusted by increase of piston speed with consequent dangers.

In the Andover system it was thoroughly demonstrated, within a few months, that it was neither safe nor economical to run a 12 x 24 x 12 x 18 inch compound duplex pump with but a single attendant at the pumping station. With the pump running at full speed it was not safe for the engineer to go 20 feet away from the pump. With every precaution which could be taken, the danger of depending upon one pump in operating such a system was considered too great. Having learned wisdom from experience, we called for designs and proposals from a number of the most reputable builders of pumping machinery, and erected a vertical, cross-compound crank and fly-wheel pumping engine.

Though I should be pleased to answer any questions in regard to this engine, it would be superfluous to enter into a description of it. It is sufficient to say that it is easily controlled and its speed is automatically governed.

With this type of engine the dangers existing in operating the direct acting pump are entirely overcome. A draft of any amount of water in any part of the system is automatically cared for, and the pumping station is now operated by one attendant with less work and worry than formerly when two men were employed.

The following incident will illustrate the difference in the amount of attention required. About six weeks ago a 6-inch blow-off gate on the force main, at an elevation of 39 feet, blew out while the pumps were running at their normal capacity. The draft was so great that no water could be obtained at an elevation of 156 feet, yet although the gage showed a drop of pressure from 130 to 40 pounds, the engine did not vary one revolution per minute in speed, and it was some minutes before the engineer realized that something had happened.

As regards safety and convenience, the crank and fly-wheel type of engine has certainly been very successful at Andover; the showing as regards economy has been equally satisfactory.

The expense of operating the direct acting duplex pump for the year 1895, when the quantity pumped was, according to displacement, 117,857,305 gallons, was as follows: —

Fuel	$1,186.07
Attendance	1,203.96
Oil, waste, and supplies	106.33
Total	$2,496.36

In 1897 the total expense of operating the crank and fly-wheel engine 1,471.5 hours and the direct acting pump 203.5 hours was: —

Fuel	$750.88
Attendance	926.25
Oil, waste, and supplies	213.15
Total	$1,890.28

or $606.08 less than the total expense in 1895.

The cost per million gallons was $21.18 in 1895 and $16.33 in 1897, showing a saving of $4.85 per million gallons. Taking the year 1897 only, the direct acting pump was run 203.5 hours, with a coal consumption of 53,100 pounds or 261 pounds per hour, while the crank and fly-wheel engine was run 1,471.5 hours, with a coal consumption of 228,190 pounds or 155 pounds per hour — a saving of 106 pounds of coal per hour.

Perhaps a better comparison is obtained by computing the cost of operation of the two pumps, taking an average figure for the price of coal. The total running time in 1897 was 1,675 hours. In this time the saving in coal by using the crank and fly-wheel engine instead of the direct acting pump would be 177,550 pounds, or about 79 tons. Taking the cost of coal as $4.50 per ton in the shed, the saving in fuel would amount to $355.50 for the year. The actual saving in attendance in 1897 over 1895 was $277.77, while the cost of oil and supplies was $106.72 more in 1897 than in 1895. This makes the total saving for the year $526.55.

The cost of installing the direct acting pump was	$ 9,041.44
" " " " " crank and fly-wheel engine was	13,368.36
Difference	$4.326.92
Interest on difference, at 4 per cent	$173.08
Five per cent depreciation on difference	216.35
	$389.43

Subtracting these figures from the saving of $526.55 in running expenses shows a net annual saving of $137.12 in favor of the crank and fly-wheel engine. As the quantity of water pumped increases, this saving will be largely increased.

The smaller water works plants are frequently, it seems to me, constructed without sufficient investigation into the relative economy of the different kinds of machinery required. The first cost is often the only consideration. At the present time any device or appliance which will save 4 per cent interest and a reasonable depreciation on its cost is a judicious investment, and it is false economy to install any appliance solely because its first cost is small.

DISCUSSION.

MR. QUINN. I would like to find out from Mr. Smith how he regulates the speed of a crank and fly-wheel engine, and also of the direct acting engine?

MR. SMITH. The speed of the crank and fly-wheel engine is reduced automatically by the governor, and it also cuts off shorter on the high pressure cylinder. It really creates a back pressure or reverse curve on the card. It is only momentary. In regulating the speed of the direct acting engine, there are three ways to do it: by the cushion valves, by the throttle valve, or by the cross-exhaust. The last is of course an expensive way. If you use your cushion valves you have got to jump around pretty lively on a quick change of speed. By the throttle valve is the only way it can be done practically.

MR. GEORGE J. FORAN. Mr. Smith, perhaps unintentionally, demonstrates that under ordinary conditions his *high duty pumping engine* would not, at least to date, have proved a paying investment. I go still farther; it ought not to be even at Andover. I have taken up this discussion, believing it to be, in the long run, as important to the salesman or manufacturer as to the members of this Association, purchasers and operators of pumping engines, that all claims for the superiority of the high duty engine should rest upon a solid, unequivocal basis.

First. Mr. Smith essays to show that IF his high duty engine exclusively had done the pumping for 1897, a net saving of $137.12 would have resulted, above the cost for operating the direct acting engine, taking into account difference in investment, interest, depre-

ciation, attendance, etc.; to obtain this figure the high duty engine is credited with a saving of $277.77 in attendance, because, we are told, the unusual severity of the service renders the operation of a direct acting engine unsafe without extra attendance; that is to say, under ordinary conditions had the high duty engine done the entire pumping, a net *loss* of $140.65 ($277.77 — $137.12) would have resulted, even at the same cost for attendance. It would be an insult to the intelligence of this Association to discuss the relative cost of attendance upon a high duty and direct acting engine under ordinary conditions — we all know the loss would be even greater than stated above, and without doubt, Mr. Smith would agree with this statement.

Second. Mr. Smith's comparison of the two engines with the resultant condemnation of the direct acting as unsafe is absolutely unjust. Here is a service claimed to be unusually severe, for which certainly some regulation should be provided — the high duty engine is fitted with its governor which fulfills this requirement, and, in answer to a question, Mr. Smith states the direct acting engine is "regulated by the throttle, the cushion valves, and the cross-exhaust" — in other words, when something happens, the attendant who is obliged to stay near by for that purpose jumps to the direct acting engine and attempts to adjust it. An automatic device would be cheaper. It is quite certain if the fly-wheel engine were similarly operated without a governor, extra attendants would be desirable if they could be induced to stay in the station. It is equally certain that a device for automatically regulating the direct acting engine could be attached which would render it absolutely safe — so simple as to offer no difficulties to any member of this Association, and so cheap as not to be worth considering as a modifying investment. This places the Andover plant on the same basis as an ordinary plant as regards attendance.

The remainder of this discussion is not essential to the main facts above stated. Space will not permit of a detailed criticism, but I would like to bring up a few points of interest.

(*a*) In 1897 the engines pumped 259 days or 1,675 hours in all, that is, approximately, 6½ hours per day of pumping. It seems too bad the direct acting engine should have pumped 203½ hours of this time. The yearly report partially explains this, as, according to the original contract, the high duty engine was "taken down and examined for wear in its various parts and found in excellent condi-

tion" ; nevertheless, the actual figures for 1897 are seen to be different from the assumption in Mr. Smith's paper. This may never happen again, but it will be just as well to retain the direct acting engine "in case."

(*b*) "The danger of depending upon one pump in operating a system like this was considered too great," etc. Had a second direct acting engine been bought, the price would have been considerably less than for the first. Nevertheless, the difference in investment (presumably including foundations) is based upon the price of the first engine with no deduction for depreciation. Properly considered, this makes the showing still worse. (See *d*.)

(*c*) Depreciation is figured upon the difference of investment. It is questionable whether both types should be figured at the same depreciation. Depreciation is dependent upon several conditions — principally wear and tear and permanency — and the wear and tear on an engine not in use is not excessive. However, this is unimportant. Presumably the new [high duty] engine will be in active service longer than the first — in this connection it would be interesting to know the depreciation allowed on the first engine. That investment has doubtless been transferred very properly to some other account. (See *d*.)

(*d*) Briefly, the first engine is no longer an active producer. The interest and depreciation upon its value must be earned by the new engine, but is chargeable to insurance or guarantee of safety, or some similar account. It has ceased to be a direct earning investment. If, for argument, Mr. Smith desires to show what the direct acting engine would have done in 1897 if no new engine had been bought, he must give it full credit for all depreciation up to that time. He would hardly want to do this, and it is hardly fair. A second engine had to be bought, and the real question is, What was the result of buying a high duty rather than direct acting engine? In that discussion we must compare the costs of the two engines if bought at the same time under the same conditions, putting them on a level basis regarding depreciation, conditions of market, and competition.

(*e*) Referring to the various Andover reports, I estimate the duty of the direct acting engine for 1897 is not quite so good as in previous years, possibly because working against somewhat higher pressure than designed for, possibly because lack of attendance would not permit of best results; in July and August, however, the work-

ing duty for the high duty engine was over 142,000,000 foot pounds per 100 pounds of coal — so very satisfactory for an engine of 1,750,000 gallons capacity as to lead to doubts of its accuracy.

(*f*) There are many points upon which Mr. Smith could give us interesting information: the efficiency of the boilers; a few cards from the water pressure recording gage, with statements as to variation in pressure and consumption at various levels in the system, and an analysis of the increase in water pressure. The last six months of 1891 the average velocity of pumping was 1,247 gallons per minute; in 1893 it was 1,156.6; in 1897, 1,152. The pressure heads were as follows: in 1891, 300 feet for five of the six months; 1893, 300 feet every month; 1897, 330 feet nine months of the year, with a yearly average of 326.4 feet. Is this increase of head between 1893 and 1897 due to tuberculation of the pipes or changes in the method of distribution, or have the consumers moved up on the hills in anticipation of a flood when a water main bursts some day and the engine and engineer continue working in blissful ignorance of the disaster? Pumping at a less rate with larger consumption in 1897, the friction would be less than in 1891, condition of pipe, reservoir levels, and distribution remaining the same. Are the given pressures maximum or average? (The original total static head was 204.5 feet from ordinary high water in pond to high water in reservoir.) If not maximum, what is the maximum pressure? This materially affects the service and duty. The pressures are very uniform, remarkably so for a system "so difficult of operation" and with such varying pressures, or perhaps most of the consumers are at the highest level, thus rendering the amounts drawn at other levels of small importance, in which case the difficulties of pumping are not so great after all, except for some impulse on the part of the water to worry the engine *à la* Kipling. Gates have blown out in other plants without fatal results. I can endorse Mr. Smith's statement that his engineer might not notice a slight change in the speed of the high duty engine, as, when I first entered the station last summer, he was not in the building, although the engine was in operation. He did come in immediately, however, and did not seem to be worrying.

MR. SMITH. I believe I stated the position fairly in opening my paper. Mr. Foran should have understood that under ordinary conditions I believe that each type of pump must stand on its own merits until the saving in running expenses will equal 4 per cent on

the investment, and the question is one of finances wholly. I tried to bring out the fact strongly that the question of regulation was a great factor in favor of a rotative type of pump for the Andover system. Two men are still employed at the pumping station when the direct acting pumps are used; if but one attendant had been employed the expense for attendance would have been $720, or a saving of $206 more than is shown in the paper. Mr. Foran admits the need of a regulating appliance and says that a regulating device can be applied, so simple as to offer no difficulties and so cheap as not to require consideration as an investment. I confess myself dull, but I cannot conceive of such an appliance. Further, the specifications under which the high duty pump was called for gave any builder a chance to propose a direct acting pump with such a device; and although the firm with which Mr. Foran is connected submitted several proposals, no such device is mentioned by them. To go still further, when Mr. Foran or any one else has such a device which shall have been proven able to automatically adjust the speed and length of stroke of a direct acting pump, the town of Andover will be glad to purchase and install it on the direct acting pump.

The remainder of Mr. Foran's discussion has no essential bearing. I will state, however, that he labors under a wrong impression in regard to the direct acting pump at Andover, as it has never been out of commission except for repairs. As for depreciation, the cost of repairs in the case of the direct acting pump during five years of service was over 15 per cent of the first cost. The high duty pump has been in operation three years, and the cost of repairs has been almost nothing and the wear insignificant. Of the cause of the increased frictional resistance with the high duty pump running, to which Mr. Foran refers, I cannot be positive, as there have never been any weir measurements of the capacity of either pump. I can simply say that from observation I should ascribe it to there being less slip from the high duty pump and less accumulation of air in the water cylinders. It is certainly not due to any condition of the system or service, as the same change takes place at the present time and a higher lift is shown when operating the high duty pump. Another curious feature of the case is that the apparent consumption of water is less when the high duty pump is used. It should be borne in mind that all figures are made on the basis of displacement without allowance for slip.

A TEST OF THE NEW PUMPING ENGINE AT WALTHAM, MASS.

BY DEAN & MAIN, MECHANICAL ENGINEERS.

(Boston, Mass., November 19, 1898.)

The engine is a cross compound horizontal fly-wheel engine with steam jackets and re-heater, having horizontal double acting pumps located behind the steam cylinders and driven by extensions of the steam piston rods. The steam cylinders have Corliss valves. A centrifugal governor determines the point of cut-off of the high pressure valves. The low pressure cut-off is determined by hand.

The guaranteed duty of 110,000,000 foot pounds was based upon the consumption of 1,000 pounds of dry steam.

The test was made by weighing the feed water into the boiler. Near the throttle valve the steam passed through a separator and the water collected there was weighed. Between the separator and the throttle valve a calorimeter was inserted and the moisture left by the separator determined. The waste of the calorimeter was weighed with the separator drain.

The jacket and re-heater drains were allowed to run to waste.

All pipes were disconnected in such a way as to properly account for all steam and water in the system.

The duration of the test was eight hours, which is two hours less than intended, on account of an unanticipated delay in starting. As the duty was based on feed water this does not sensibly vitiate the accuracy of the test, for the hourly weights of feed water were determined and were practically equal.

PRINCIPAL DIMENSIONS.

Diameter of high pressure cylinder	22 inches
,, ,, low ,, ,,	48 ,,
,, ,, each plunger	15 ,,
Stroke of high pressure piston and plunger	$36\frac{1}{32}$,,
,, ,, low ,, ,, ,, ,,	36 ,,
Ratio of piston areas	4.76

AVERAGE TEMPERATURES.

Of engine room ..... 74° Fahrenheit
„ external air ..... 43° „
„ water in pump well ..... 56° „

AVERAGE PRESSURES.

Of atmosphere by barometer ..... 14.81 pounds
„ steam at engine by gage ..... 111.47 „
„ „ „ „ absolute ..... 126.28 „
„ vacuum by gage ..... 13.49 „
„ force main by test gage ..... 68.48 „
Corresponding head above gage ..... 158.19 feet
Average reading of float gage in pump well ..... 14.47 „
Distance between zero of float and center of gage on force main ..... 4.28 „
Total dynamic head ..... 176.94 „

STEAM USED BY ENGINE.

Total moist steam delivered to engine in eight hours .. 19,874 pounds
Water drained from separator, and calorimeter waste .. 538 „
Steam delivered to throttle by separator ..... 19,336 „
Moisture in steam at throttle by calorimeter ..... 1.32 per cent
Dry steam delivered to engine ..... 19,081 pounds

WORK DONE BY ENGINE. — DUTY.

Average number of revolutions per minute 32.38
Volume displaced by plungers in eight hours .. 222,737.74 cubic feet
Weight of same at 62.39 pounds per cubic foot .. 13,896,608 pounds
Work done by plunger in eight hours, 13,896,608 pounds × 176.94 feet = ... 2,458,865,819 foot pounds
Duty per 1,000 pounds of dry steam, 2,458,865,819 ÷ 19.081 = ... 128,865,000 „ „
Excess over guarantee, 18,865,000 foot pounds = ... 17.15 per cent
Work done by plungers per minute ..... 5,122,638 foot pounds
Pump horse-power, 5,122,638 ÷ 33,000 = ... 155.23 horse-power
Indicated power of steam cylinders[1] ..... 167.08 „
Approximate friction of engine, 167.08 — 155.23 = ... 11.85 horse-power = 7.1 per cent
Approximate efficiency of mechanism ..... 92.9 per cent

The engine was built to pump against about 273 feet dynamic head, instead of 176.94 feet, but this could not be obtained on account of projected extensions of the water works not having been carried out. Furthermore the boiler pressure of 150 pounds promised by the speci-

[1] This is approximate and was determined from only two sets of indicator diagrams.

fications could not be carried on account of the low head. The boiler pressure used was 113.1 pounds. If the pressure had been 150 pounds, the pressure at the engine would have been about 147.5 pounds by gage, or 162.3 pounds absolute, instead of 126.28 pounds absolute. On the principle that the steam consumption of an engine is nearly proportional to the logarithms of the steam pressures, the duty would have been about 135,000,000 foot pounds with the higher pressure. Moreover, if the greater head had existed, the duty would have been a little greater because less relative work would have been consumed by the friction of the engine and pumps.

On account of a slight derangement of a valve gear detail the engine was slowed down a little after running a few hours and averaged 0.95 of a revolution per minute, during the whole test, less than that required by the specifications, and therefore fell a little short of the required capacity. It had, however, on a sufficient number of other occasions shown its ability to give more than the normal capacity.

This engine is a good specimen of designing and building, possesses ample stability for reliable service, and the duty is among the highest recorded for compound engines.

Respectfully submitted,

(Signed) DEAN & MAIN.

ROCEEDINGS OF THE EIGHTEENTH ANNUAL CONVENTION.

September 13, 14, and 15, 1899.

On Tuesday, September 12, many of the members *en route* to the convention at Syracuse visited the new filter plant and pumping station at Albany, N. Y., which were explained by Mr. Allen Hazen, the designing and constructing engineer, and Mr. George I. Bailey, Superintendent of the Albany water works.

SYRACUSE, N. Y.,
September 13, 14, and 15, 1899.

The headquarters of the Association during the convention were at the Yates Hotel, and the meetings were held in Assembly Hall, on the fifth floor of the hotel building.

The following members and guests were in attendance: —

ACTIVE MEMBERS.

Charles H. Baldwin, Lewis M. Bancroft, George B. Bassett, Joseph E. Beals, James F. Bigelow, Forrest E. Bisbee, James W. Blackmer, George Bowers, Fred. Brooks, James Burnie, William F. Codd, Charles D. Colson, Byron I. Cook, Henry A. Cook, F. H. Crandall, George K. Crandall, J. W. Crawford, George E. Crowell, William E. Davis, William Downey, E. R. Dyer, F. F. Forbes, J. H. Gamwell, D. H. Gilderson, Albert S. Glover, Amos A. Gould, Fred. W. Gow, John C. Haskell, L. M. Hastings, W. C. Hawley, Allen Hazen, W. R. Hill, James A. Huntington, William S. Johnson, Willard Kent, Patrick Kieran, Louis H. Knapp, Harry A. Lord, A. E. Martin, Leonard Metcalf, Thomas Naylor, F. L. Northrop, W. Paulison, John H. Perkins, J. B. Putnam, A. H. Salisbury, M. A. Sinclair, H. O. Smith, H. T. Sparks, George A. Stacy, J. C. Sullivan, J. G. Tenney, R. J. Thomas, William H. Thomas, John Venner, C. K. Walker, E. L. Wallace, John C. Whitney, George E. Winslow, E. T. Wiswall — 60.

HONORARY MEMBER.

F. W. Shepperd — 1.

ASSOCIATE MEMBERS.

Coffin Valve Co., by H. L. Weston; Hersey Mfg. Co., by J. A. Tilden, Samuel Harrison, and Fred A. Smith; National Meter Co., by J. G. Lufkin; Neptune Meter Co., by D. B. McCarthy; New York Filter Mfg. Co., by Charles Wilson; Pittsburg Meter Co., by F. H. Gillespie; Rensselaer Mfg. Co., by Fred. S. Yates; Ross Valve Co., by William Ross and J. C. Ross; A. P. Smith Mfg. Co., by W. H. Van Winkle; Thomson Meter Co., by S. D. Higley, Henry C. Folger, and E. J. Snow; Union Water Meter Co., by J. P. K. Otis; U. S. Cast Iron Pipe & Foundry Co., by A. H. Lang; H. R. Worthington, by H. S. Wilson and Joseph W. Roe — 19.

GUESTS.

E. A. Fuertes, W. E. Mott, Ithaca, N. Y.; Mrs. J. G. Tenney, Leominster, Mass.; John L. Wetherley, *Syracuse Journal;* Mrs. H. O. Smith, Leicester, Mass.; James Burns, Mrs. James Burns, Lynn, Mass.; Fred. C. Gamwell, Palmer, Mass.; Mrs. Joseph E. Beals, Middleboro, Mass.; Walter H. Sears, Plymouth, Mass.; Mrs. H. A. Lord, Ogdensburg, N. Y.; Mrs. F. S. Yates, Troy, N. Y.; Mrs. W. Paulison, Passaic, N. J.; Mrs. George A. Stacy, Mrs. N. Willard, Marlboro, Mass.; Mrs. Thomas Naylor, Maynard, Mass.; W. W. Trowbridge, West Newton, Mass.; L. M. Hudson, L. B. Lawrence, Thomas Burke, J. B. Wood, Edward S. Murphy, Marlboro, Mass.; C. E. Riley, Brookline, Mass.; G. S. Hook, Oneida, N. Y.; George F. Rowell and G. H. Patridge, *Engineering Record;* George E. Pickering, Boston, Mass.; Eddy Valve Co., by Robert Kinnear; Mrs. E. L. Wallace, F. G. Judkins, Mrs. F. G. Judkins, Franklin Falls, N. H.; Mrs. L. M. Hastings, Cambridge, Mass.; Mrs. George E. Winslow, Waltham, Mass.; William B. Littlefield, Mrs. Littlefield, Lynn, Mass.; William P. Baker, *Syracuse Herald;* Mrs. D. H. Gilderson, Haverhill, Mass.; Mrs. William F. Codd, Nantucket, Mass.; M. J. Dowd, August Fels, Mrs. Fels, Mrs. George Bowers, A. J. Barrett, Mrs. Barrett, Lowell, Mass.; Mrs. Willard Kent, Narragansett Pier, R. I.; James P. Bacon, Mrs. Bacon, Cambridge, Mass.; Mrs. A. H. Salisbury, Lawrence, Mass.; H. C. Hodgkins, Syracuse, N. Y.; A. N. Russell, Ilion, N. Y.; Daniel N. Tower, Mrs. Tower, Cohasset, Mass.; Mrs. William H. Thomas, Miss Helen A. Thomas, Hingham, Mass.; G. F. Comfort, Syracuse, N. Y.; Mrs. Fred. W. Gow, Medford, Mass.; John G. Seward, Norwich, N. Y.; Mrs. J. B. Putnam, Westboro, Mass.; J. M. Anderson, Mrs. Anderson, Worcester, Mass.; Mrs. Charles H. Baldwin, Boston, Mass.; Mrs. Louis H. Knapp, Miss Ethelind Knapp, Frank J. Illig, Buffalo, N. Y.; Charles S. Warde, Staten Island, N. Y. — 65.

Total attendance, 145.

EXHIBITS.

The exhibits of the Associate Members were in charge of Mr. W. H. Van Winkle, of the A. P. Smith Manufacturing Co.

The HERSEY MANUFACTURING CO. showed a pyramid of Hersey meters of various sizes, fastened to a stand made of iron pipe. The H. MUELLER

MANUFACTURING CO. had an exhibit comprising cocks of all kinds, tapping machines, and other appliances of their manufacture. The THOMSON METER CO. had a display of Lambert meters of various sizes. The A. P. SMITH MANUFACTURING CO. showed their apparatus for making connections with water mains of any size up to 48-inch; a steam calking machine; a new lead kettle; and various tapping machines, sleeves, plugs, and other appliances. The NEPTUNE METER CO. exhibited Trident meters of various sizes. The ROSS VALVE CO. displayed some of its valves and other specialties. The PITTSBURG METER CO. had a good assortment of meters, in bronze and galvanized iron. The merits of the valves and hydrants made by the EDDY VALVE CO. were fully set forth, as were those of the RENSSELAER MANUFACTURING CO. The new pattern of the Walker patent fire hydrant was exhibited by the COFFIN VALVE CO. The Union and Columbia meters, made by the UNION WATER METER CO., were displayed by that company. The WALWORTH MANUFACTURING CO. exhibited the Hall tapping machine, Walworth gate valves, and a variety of water works tools. The NATIONAL METER CO. had samples of the various brands of meters of their make. The WORTHINGTON meters were also exhibited. The LEAD-LINED IRON PIPE CO. displayed samples of straight pipe, curves, branches, etc., in lead-lined and tin-lined pipe.

WEDNESDAY, SEPTEMBER 13.

The convention was called to order at 11 A.M., by President Forbes, who called upon Mr. William R. Hill to present the Mayor of the city to the Association.

MR. HILL. *Mr. President and Gentlemen of the New England Water Works Association*, — How glad the citizens of our city are to welcome you here will be told you by a gentleman who had at one time the distinguished honor of being the youngest Mayor of any city in the United States; and if his health continues good I have no fear in saying that perhaps at some day he will have the distinguished honor of being the oldest Mayor of any city in the United States. I have the honor of introducing to you, gentlemen, our Mayor, the Honorable James K. McGuire. [Applause.]

Address of Welcome by Mayor McGuire.

Mr. Hill, Mr. President, and Gentlemen of the New England Water Works Association, — It is hardly necessary for me to say that after the exceedingly fulsome eulogy, of which I consider myself the undeserving recipient, I scarcely know what to say to you. I am very glad that I kept running for Mayor of Syracuse until I lost the title of "Boy Mayor." There was nothing that at first made me feel so

much ashamed of myself as to be introduced everywhere about the country in about the same way that a fakir would introduce a freak in a museum or a curiosity in a circus, as the "Boy Mayor." Everybody would naturally expect an exhibition by me of some peculiar boyish antics, and it was the fashion for a long time here in the city — I am glad to say we have outgrown that now — to put me in occasionally as the pitcher for the local baseball team, to select me as referee for a football match, and to ask me to do many things except serious things. But I am glad that my friend Mr. Hill acknowledges that I have been Mayor long enough to have outgrown my youthful title. Yet, after all, we are all boys only of a larger growth; and judging from some observations that I have made from the windows of the City Hall during the past twelve hours, some of the members of the New England Water Works Association are old boys and rather frisky ones. [Laughter.]

I am sure that I voice the prevailing opinion in Syracuse when I say that one and all we are profoundly grateful to you for having come to our beautiful little city. We here in the money-making and money-mad State of New York appreciate the culture and the intellect of New England, before which we all reverently bow. I know that the members of this Association in their own cities have been surfeited with speeches from the various orators who have made New England famous throughout the world. You come from a section of the country which can boast of orators of the past, such as Wendell Phillips and Daniel Webster and William Lloyd Garrison, and of speakers of the present day like Mr. Lodge and Mr. Collins and Mr. Hoar, and I presume a man would be daring indeed who would venture to mention before a New England audience the name of Edward Atkinson. [Laughter.] But the fact that you have been accustomed to sit at the feet of such distinguished orators makes us practical New York Tammany or Platt politicians hesitate about addressing you, gentlemen from New England, who are so totally unfamiliar with and so innocent of the real meaning of that hated word "practical" politics. We often notice at national conventions that the delegates from New England, especially from Massachusetts, seem to wear a most superior air. And while apparently these delegates are very independent, and come to conventions wholly uninstructed, we have noticed with what remarkable facility and how quickly gentlemen from Maine and New Hampshire and Connecticut and Massachusetts are able to get onto the band wagon and join the

winners somehow, even though they are outside of the machine. [Laughter.]

It was a very creditable action on the part of our efficient superintendent of the Syracuse Water Department to secure the holding of your present convention in this city. And I am bold enough to say that after you have observed the workings of our water department, and seen the operation of our most successful system, you will go away feeling satisfied with your visit, and knowing that you have obtained some very useful and interesting information. And I am glad to take advantage of this opportunity publicly to pay my tribute to the ability, the industry, and the energy of Mr. William R. Hill [applause]; and I can venture to assure this assemblage, speaking as a very practical politician, that whatever political party chances to be dominant in the municipal affairs of the city of Syracuse, no political party would dare, in the face of an overwhelming public sentiment, to change the superintendent of the Syracuse Water Department. [Applause.] To him and to the efforts of the Water Board, who have complete confidence in him, has been due the notable success of our water system. I think that the administration of that department is a complete answer to all the objections that have ever been made to the municipal ownership and operation of water plants. We here in Syracuse for years had been subject to exorbitant charges for water and to a very inferior system of distribution. Public sentiment became aroused to the necessity of the city owning and controlling its own water supply, and the result of the agitation and work is the possession now by the city of Syracuse of this beautiful Skaneateles Lake and of this magnificent water system of which we so proudly boast. I think that under municipal ownership the water is supplied considerably more than one half cheaper than it was under private ownership; and in addition to that, the city is abundantly supplied with pure and wholesome water. Our water works to-day stand as an object lesson for the whole United States.

Mr. Hill, as the superintendent of the water department, has also demonstrated the success of what may be termed the day-labor plan in extending the water works distributing system throughout the city. Formerly the mains were laid by the contract system, but Mr. Hill prevailed upon the Water Board to change to the day-labor system, and his report upon that subject furnishes very interesting reading. The day-labor system has often been objected to as extravagant on the ground that an unnecessarily large number of men would be

employed, and that politics would enter into the work to such a degree that it would be much more expensive than the contract system. But where we have an efficient, practical business man at the head of the department, such as we have here in Syracuse, we will be able to prove to you that the laying of pipe under the day-labor plan is more economical from the standpoint of the taxpayers and more efficient from the standpoint of good work. We invite your attention to that fact as demonstrated in Syracuse.

It would be wholly out of place for me as a layman to attempt to talk technically of the advantages of our water works to you, gentlemen, who are all hard-headed practical men. It is simply my pleasure to bid you a cordial welcome in the name of the one hundred and thirty thousand men, women, and children who make up the population of this municipality of ours. I bid you welcome in the name of all the people of Syracuse. I trust that your stay among us will be pleasant, and that when you return to New England you will carry with you the pleasantest recollections of your visit to this inland metropolis of the Empire State. I thank you very kindly for your courteous attention. [Loud applause.]

Response by President Forbes.

Mr. Mayor, — In behalf of the New England Water Works Association, I desire to thank you for your cordial welcome. I assure you that the members and guests of our Association will heartily appreciate all you may do for us while we are in your city. And I take this opportunity to extend an invitation to you and through you to the citizens of Syracuse to attend any or all of our meetings, and to take part in our discussions. I think Mr. Hill deserves great credit for the program he has laid out for our pleasure and instruction. We have heard a great deal about the thrift, the energy, and the hospitality of the people of Syracuse and of the natural beauties of your city, and we are glad to be able to see and realize for ourselves that the accounts which have reached us are not exaggerations, but plain truths. [Applause.]

ELECTION OF NEW MEMBERS.

The Secretary read the names of the following applicants for membership, they having been approved and recommended by the Executive Committee.

Resident Active.

James Burns, Water Commissioner, Lynn, Mass.

Charles E. Riley, member Water Board, Brookline, Mass.

J. H. Stubbs, Superintendent Streets and Water Works, St. Albans, Vt.

Walter H. Sears, Water Works Construction Engineer, Plymouth, Mass.

August Fels, member Water Board, Lowell, Mass.

Non-Resident Active.

Clarence W. Hubbell, Engineer Water Works, Detroit, Mich.

Frank J. Illig, Superintendent of the Water Department, Buffalo, N. Y.

A. N. Russell, President Board of Water Commissioners, Ilion, N. Y.

S. Hook, Civil Engineer, Oneida, N. Y.

On motion of Mr. Kent the Secretary was directed to cast the ballot of the Association in favor of the applicants, which he did, and they were declared by the President elected to membership.

The President then delivered his annual address, which follows.

THE PRESIDENT'S ADDRESS.

Gentlemen of the New England Water Works Association, — The Association meets to-day for its eighteenth annual convention, and for the first time in its history outside of New England. We may reasonably expect that a meeting held so far from home, and under unusual surroundings, will give new experiences and ideas to the members, and in the end result in much good to all.

Mr. Willard Kent, the President of the Association for 1898, in his annual address, very aptly alluded to the growth in numbers of our Association, to its great importance, and to the influence it is capable of exerting on all matters relating to the problem of supplying pure water to the people.

There seems to be no better subject for this brief address than the public good which our Association can do, and which it ought to do, with a few suggestions as to the way such a desirable end may be obtained. A president who has occupied the chair for one year realizes at the expiration of his office, more fully perhaps than any

other man in the Association, the amount of information this Association is capable of imparting to all those who are interested in water supply questions.

It is well to bear in mind the fact that our membership roll contains the names of nearly all the prominent men in this country and in Canada who are grappling with the great water supply problems of the day, as well as most of the superintendents from the small cities and towns of New England, and a great many from the small cities and towns outside of this area, — a large army of scientific and practical workers. The knowledge which exists, therefore, among us must be most extensive and varied, and our Association should not only give the fullest expression to the most scientific minds, but the purely practical man should receive equal consideration, and our *Journal* should print alike matters relating to theory and practice.

We all realize that we are ever moving on, and we must not for one moment consider that our knowledge to-day is sufficient for to-morrow, but is rather another step on which to mount and reach still higher. I think no one will dare to say that the limit of knowledge of water works problems is reached, especially when he carefully reviews the enormous progress made during the last quarter century; and undoubtedly the water works official who lives fifty years from this time will look back with a kind of pity upon those who managed the water systems in 1899.

Keeping, then, in mind the fact that increased knowledge will come, why should not our Association lead instead of follow? Why should not only this country, but the world turn to the publications of this Association for the latest information concerning everything relating to water works? We possess advantages for obtaining information which no weekly or monthly publication possesses, having among our members, as just stated, the men who design, and the men who have the rich experience of maintaining the things designed.

We hardly need to state that the value of a thing is not in the beauty of its design alone, but rather in its ability to stand the wear and tear of daily use. A water gate, for instance, may open and shut easily, and may be tight; but when the time comes to pack the spindle, the stuffing box may be so made that new packing cannot be inserted without cutting the gate out of service, — a serious defect, but not discovered, perhaps, until repairs were needed. This is only one of a thousand things which might be mentioned relating to the practical part of our work.

We all know that the knowledge in the world to-day is simply the sum of experience. As a graphic illustration I might state that the magnificent Atlantic liner of to-day has developed from a dug-out canoe. Experience to be of value must be recorded in such a way that it can be found when required.

Now let us look closely to the possibilities of our Association for accumulating and disseminating knowledge. As I have before stated, our Association includes nearly all of the leading specialists in this country in all branches of hydraulic subjects, as far as they relate to supplying cities and towns with water for domestic and fire purposes. These men should be induced to make our *Journal* one of the means, if not the chief means, of giving expression to their ideas and experiences. An account of all large and all important engineering works should be published with illustrations. Engine tests should not go unnoticed. Failures of all kinds should be recorded. We have a small army of men whose lives are spent in the maintenance of water works, yet we hear very little from the most of them. All should be encouraged to accustom themselves to make careful notes of their work, and present to the Association all information of value. In other words, our *Journal* should be made, and can be made, a great history of all water works subjects.

The *Journal* can also become more useful by printing, in a brief way, such parts of the annual reports of the various cities and towns as are of permanent value. The Massachusetts State Board of Health is now doing a great and good work in a study of the action of water used for domestic purposes on lead service pipes. This Board is accumulating information on this subject which is new, and which will be of great public good. Much of this information will appear in their next annual report; but comparatively few will have access to this report, and the results of these studies should be printed in our *Journal*. I cite this case as only one of many.

I do not doubt that the interests of the Association can be promoted by the employment of a permanent secretary, if the right man can be obtained, who shall give his whole time to the business of the Association, and shall also act as senior editor of the *Journal*. By such an arrangement, much useful information can be brought before the Association which would not otherwise be obtained. I hope the time is not far distant when this arrangement can be effected, but under the present rate of annual assessment the means of the Association are not sufficient to meet the additional expense.

In this connection I wish to speak of the library in the rooms of the Association in Tremont Temple Building, Boston. I should greatly favor an annual expenditure of one hundred dollars or more for the purchase of books which relate to water works matters to be added to the library. Very few of us can ever expect to have a complete library dealing wholly with hydraulic subjects, and the benefit to the members of an opportunity to consult such a library as the one at our headquarters can be made would be very great, and would be worth many times over the cost to the members. I hope that some action will be taken at this meeting favorable to the above recommendation.

I am also of the opinion that our by-laws should be revised to meet the present needs of the Association. I hope this matter can be looked upon without any prejudice, and in a strictly business manner, and that a committee will be appointed at this meeting to take this matter in hand.

The usual meetings have been held during the year. At the winter meetings a successful attempt was made to have only one subject considered at each meeting. The idea was to bring together as much information as possible on one subject at one time, and have it recorded for future use. None of the subjects introduced at the winter meetings were exhausted by any means, although the papers were numerous, and were presented by men of recognized ability.

There is one phase of our meetings which I wish to emphasize, and that is the benefit derived from the informal exchange of ideas outside of the hours of business session. I think this is the most pleasant way of obtaining information, and that it should not be disregarded by any member. Even if new ideas are not always obtained, it is a great satisfaction to know that we are at the front.

Death, who shows favors to no one, has taken from our number during the past year the following members: Lemuel Ameoman, C.E., Scranton, Pa.; George E. Batchelder, Water Registrar, Worcester, Mass.; David B. Kempton, Chairman Water Board, New Bedford, Mass.; Charles F. Murphy, Inspector, Marlboro, Mass.; Edward C. Nichols, Water Commissioner, Reading, Mass.; Charles H. Swan, C.E., Boston, Mass.

The report of the Treasurer and Secretary, immediately following this address, will give the necessary information relating to the finances and membership of the Association.

In conclusion, I wish to thank all of those who have so generously

contributed papers, and have coöperated in other ways to make the meetings of the past year of permanent value to those interested in water works problems — some of the most vital problems of the age.

I hope the future will show even increased activity, and that all will strive to add something to the world's great storehouse of wisdom.

REPORT OF FINANCE COMMITTEE.

Mr. W. F. Codd, for the Finance Committee, reported that the Committee had examined the accounts of the late George E. Batchelder, as Treasurer of the Association, and found them correct. The Committee submitted the following report, which was accepted and placed on file.

REPORT OF THE TREASURER, GEORGE E. BATCHELDER, IN ACCOUNT WITH THE NEW ENGLAND WATER WORKS ASSOCIATION.

RECEIPTS.

1898.	Balance on hand as per last report:		
	City National Bank	$ 346.41	
	People's Savings Bank	1,161.04	
	Safe Deposit & Trust Co.	1,429.47	
			$2,936.92
October 20.	Received from J. C. Whitney, Secretary	$600.00	
December 16.	" " " " "	150.00	
" 31.	" " " " "	200.00	
1899.			
January 11.	" " " " "	100.00	
" 26.	" " " " "	350.00	
			$1,400.00
February 1.	People's Savings Bank, interest	$ 22.99	
July 1.	City National Bank, "	1.92	
" 1.	Safe Deposit & Trust Co. "	37.54	
			$ 62.45
			$4,399.37
July 1.	Bills paid by J. C. Whitney, Secretary		563.26
			$4,962.63

EXPENDITURES.

1898.		
July 15.	Boston Society of Civil Engineers	$50.00
September 1.	W. H. Richards	77.00
" 29.	Electro Light-Engraving Co.	7.30
" 30.	Bacon & Burpee	65.00

October 10.	J. C. Whitney	$125.00	
„ 10.	„ „	122.08	
„ 13.	Electro Light-Engraving Co.	8.55	
„ 14.	„ „ „	2.50	
„ 24.	Newton Journal	38.85	
„ 27.	W. T. Almy	13.20	
November 1.	Day Publishing Co.	250.04	
„ 5.	Fanning Printing Co.	45.00	
December 1.	W. H. Richards	81.95	
„ 1.	J. C. Whitney	125.00	
„ 1.	„ „	35.20	
„ 15.	Electro Light-Engraving Co.	12.58	
October 1.	Frank A. Andrews	10.18	
„ 15.	Boston Society of Civil Engineers	100.00	
December 10.	Newton Journal	6.00	
„ 31.	Henry F. Jenks	25.00	
1899.			
January 11.	Beethoven Quartette	25.00	
„ 12.	Day Publishing Co.	182.16	
„ 13.	Thomas P. Taylor	10.00	
			$1,417.59

PAID BY J. C. WHITNEY, SECRETARY.

February 2.	Electro Light-Engraving Co.	$ 16.95	
March 8.	Francis L. Pratt	30.00	
„ 9.	Thomas P. Taylor	20.00	
„ 13.	W. H. Richards	107.43	
„ 22.	Boston Society of Civil Engineers	100.00	
„ 24.	Electro Light-Engraving Co.	30.15	
„ 28.	Day Publishing Co.	230.79	
„ 31.	Newton Journal	9.94	
April 1.	H. F. A. Lange	10.00	
„ 16.	R. H. Woodhouse	8.00	
			$ 563.26
			$1,980.85
	Error in payment		8.00

BALANCE ON HAND.

July 1.	Transferred to Worcester National Bank	$1,467.01	
„ 1.	City National Bank	322.74	
„ 1.	People's Savings Bank	1,184.03	
			$2,973.78
			$4,962.63

Respectfully submitted,

A. W. F. BROWN,
WM. F. CODD,
HORACE KINGMAN,
Finance Committee.

August 2, 1899.

REPORT OF TREASURER BANCROFT.

Mr. Lewis M. Bancroft, who was elected Treasurer in place of Mr. Batchelder, deceased, read the following report, which was accepted and placed on file.

LEWIS M. BANCROFT, TREASURER.

In account with New England Water Works Association.

RECEIPTS.

1899.			
August 2.	Received from Finance Committee:		
	Deposit People's Savings Bank . . .	$1,184.03	
	" Worcester National Bank . .	1,467.01	
	" City National Bank	322.74	
		$2,973.78	
September 2.	Received from J. C. Whitney, Secretary . .	800.00	

EXPENDITURES.

August 30.	W. H. Richards, salary to June 1, 1899, postage, telegrams, etc.		$ 82.38
	C. A. W. Spencer, printing tables . . .		13.00
	Bacon & Burpee, report of winter meeting .		76.75
	Newton Journal, printing envelopes, bills, etc.		15.45
	Electro Light-Engraving Co., engraving plates		38.45
September 4.	C. H. Curtis, caterer		62.50
	Lynn & Boston Railroad, car fares June meeting		18.00
	Boston Society Civil Engineers, rent to June 1, 1899		150.00
" 5.	Samuel Hobbs & Co., envelopes, letter-book, and Journal		4.40
	W. N. Hughes, envelopes and printing . .		2.25
	J. M. Ham, salary February 15 to August 18, 1899, postage and express		162.16
	The Day Publishing Co., printing June Journal		436.04
			$1,061.38

BALANCE ON HAND.

People's Savings Bank . . .	$1,184.03	
Worcester National Bank . . .	1,467.01	
City National Bank	9.56	
First National Bank, Reading . .	51.80	
		2,712.40
	$3,773.78	$3,773.78

LEWIS M. BANCROFT.

REPORT OF THE SECRETARY.

The Secretary submitted the following report, which was received and placed on file.

SUMMARY OF STATISTICS RELATING TO MEMBERSHIP FOR YEAR ENDING JUNE 1, 1899.

ACTIVE MEMBERS.

June 1, 1898.	Total active membership		488	
	Withdrawals during year		15	
			473	
	Initiations.			
	September, 1898	7		
	December, 1898	4		
	January, 1899	3		
	February, 1899	2		
	March, 1899	5		
		21		494

HONORARY MEMBERS.

June 1, 1898.	Honorary members	5	
„ 1, 1899.	„ „		5

ASSOCIATE MEMBERS.

June 1, 1898.	Total associate membership		77	
	Withdrawals during year		5	
			72	
	Initiation, February, 1899		1	
				73
June 1, 1899.	Total membership			572

Mr. W. R. Hill, Superintendent and Engineer, Syracuse, N. Y., then addressed the convention, explaining his method of removing vegetable organisms from the water in the distributing reservoir of the city of Syracuse. The paper was discussed by Messrs. Haskell, Fish, Hazen, Hodgkins, Forbes, and the author.

During the afternoon a visit was made to the Syracuse distributing reservoir and an exhibition by the fire department was witnessed.

EVENING SESSION.

At the evening session Allen Hazen, C.E., of New York City, gave an informal talk, illustrated with lantern slides, describing the new filter plant at Albany, N. Y.

Prof. E. A. Fuertes, Director of the College of Civil Engineering, Ithaca, N. Y., described the new hydraulic laboratory of the College of Civil Engineering, Cornell University, illustrating his description by lantern slides.

A paper descriptive of the Flood Water Channel of the Altoona, Pa., Reservoirs, by Charles W. Knight, C.E., of the Stanwix Engineering Co., Rome, N. Y., was read by Charles C. Hopkins. This was also illustrated by the stereopticon.

THURSDAY, SEPTEMBER 14.

At 9 A.M. the members and guests took a special train to Lake Skaneateles, the source of the Syracuse Water Supply. After viewing the dam and gate house at the outlet of the lake, the party proceeded by steamer to Glen Haven, at the upper end of the lake. Lunch was served there; and the return to Syracuse was made at 6 P.M.

In the evening there was a banquet at the Yates Hotel, at which speeches were made by Mr. W. R. Hill, Mr. T. E. Dwyer, Mr. Wiles, and others.

FRIDAY, SEPTEMBER 15.

In the absence of President Forbes, Vice-President Byron I. Cook called the meeting to order and announced that the first business was the election of officers.

Mr. Willard Kent in behalf of the Nominating Committee submitted a report, which was read by the Secretary, as follows: —

ASSOCIATION HEADQUARTERS, BOSTON, MASS., June 1, 1899.

The Nominating Committee submit the following list as officers of the New England Water Works Association for the ensuing year: —

President.

BYRON I. COOK, Superintendent, Woonsocket, R. I.

Vice-Presidents.

C. K. WALKER, Superintendent, Manchester, N. H.
M. A. SINCLAIR, Superintendent, Bangor, Me.
R. S. BARTLETT, Superintendent, Norwich, Conn.
W. E. HAWKS, President, Bennington, Vt.
F. E. MERRILL, Superintendent, Somerville, Mass.
T. G. HAZARD, Jr., Civil Engineer, Narragansett Pier, R. I.

Executive Committee.

P. KIERAN, Superintendent, Fall River, Mass.
J. C. HASKELL, Superintendent, Lynn, Mass.
R. J. THOMAS, Superintendent, Lowell, Mass.

Secretary.

WILLARD KENT, Manager, Narragansett Pier, R. I.

Treasurer.

L. M. BANCROFT, Superintendent, Reading, Mass.

Senior Editor.

J. E. BEALS, Superintendent, Middleboro, Mass.

Junior Editor.

C. W. SHERMAN, Asst. Supt. Metropolitan Water Works, Cambridge, Mass.

Finance Committee.

A. W. F. BROWN, Registrar, Fitchburg, Mass.
W. F. CODD, Superintendent, Nantucket, Mass.
J. W. CRAWFORD, Secretary, Lowell, Mass.

Respectfully submitted,

WILLARD KENT,
JOHN C. HASKELL,
GEORGE A. STACY,
DEXTER BRACKETT,
HORACE G. HOLDEN,
Committee.

The report of the committee was accepted and adopted, and the Secretary was instructed to cast the ballot of the Association in favor of the nominees, which he did, and they were declared elected.

President-elect Cook, after briefly thanking the Association for the honor conferred upon him, and expressing the hope that he might be able to conduct the affairs of the Association in as satisfactory a manner as had been done in the past, read a paper on "Standpipes." The paper was discussed by Messrs. Haskell, Bassett, Hawley, Beals, and Bancroft.

Prof. Gardner S. Williams, Engineer in charge of the Hydraulic Laboratory, Cornell University, next read a paper entitled "Some

Notes on the Design of Water Works Distribution Systems." Messrs. Kuichling, McKenzie, Hazen, Walker, Fish, and Haskell participated in the discussion of the paper.

George I. Bailey, Superintendent, Albany, N. Y., next read a paper entitled "The Care of Fire Hydrants in Winter."

AFTERNOON SESSION.

At the afternoon session Vice-President Walker occupied the chair.

F. H. Crandall, C.E., Superintendent and Treasurer, Burlington, Vt., read a paper entitled "Methods of Assessment and Collection of Water Rates." The discussion which followed the reading of the paper was participated in by Messrs. Walker, Kuichling, Sullivan, McKenzie, Hawley, Whitney, Hazen, Russell, and Bancroft.

Louis H. Knapp, Engineer of the water works at Buffalo, N. Y., read a paper descriptive of those works.

CLOSING EXERCISES.

Vice-President Walker. I want to say it was a long distance for an old man to come, but I am glad I came. I can think of no place where we have ever met where we have enjoyed ourselves more than we have here, and I for one want to thank the people of Syracuse for asking us to come, and for the entertainment they have given us. I never expect to come here again to a water works convention, but I can recommend Syracuse wherever I go. [Applause.]

Mr. Whitney. Before we adjourn I think it is fitting that we should put on record some slight testimonial of our appreciation of our visit to Syracuse, and also of the reception we had in the city of Albany. That we do appreciate everything that has been done for us I think our friends in Syracuse and in Albany fully believe, but I think you will all agree with me that it is well to put upon our records the following resolutions: —

Resolved, That the thanks of the members and guests of the New England Water Works Association be extended to Mr. William R. Hill, to the Syracuse Water Board, to the Reception Committee, and to the citizens of the city of Syracuse for the cordial welcome, the untiring interest, and

the lavish entertainment that they have given us, and that have so largely contributed to the notable success of this convention.

Resolved, That the thanks of the New England Water Works Association be extended to the Water Board of the city of Albany, its Superintendent and Engineer, for courtesies extended on our recent visit to the filter plant of their city.

Mr. Haskell. I would like to make the suggestion that the Secretary be authorized to send a copy of these resolutions to the various parties mentioned.

Mr. Stacy. I will move the adoption of these resolutions, that a copy be sent to the various parties mentioned in them, and that they be spread upon our records in indelible ink, and we will not forget that Mrs. Hill is included. [Applause.]

The motion was seconded by many members and adopted by a rising vote.

On motion of Mr. Stacy, there being no further business to come before it, the convention adjourned.

PRESENTATION TO MR. AND MRS. HILL.

A pleasant feature attending the closing exercises of the convention was the presentation to Mr. and Mrs. Hill of a beautiful cabinet, the gift of visiting members of the Association. A large number of them accompanied by the ladies having assembled in the convention hall, Mr. Haskell called to order and said: —

Ladies and Gentlemen in general, and Mr. Hill and Mrs. Hill in particular, — It is with heartfelt pleasure that I now present to Mr. Hill and his wife this cabinet [applause], representing as it does a slight expression of the gratitude felt by the members of the New England Water Works Association, who have been so generously entertained during this convention as the result of the efforts of Mr. Hill and his wife, assisted by the citizens of Syracuse. [Prolonged applause.]

Mr. Hill responded as follows: —

Mr. Haskell, Ladies and Gentlemen, — I am unable to thank you in a fitting manner for this very beautiful gift, but I assure you that there is already engraved upon my memory a recollection that I hope will exist for many years, of the high honor which you have paid our

city in making us this visit. While perhaps in future years memory may fade, I am pleased to have this beautiful gift which shall always remain with us and be handed down to our children to be a perpetual reminder of your kind generosity. [Loud applause.]

MRS. HILL. I wish to say that I thank you all. [Enthusiastic applause.]

OBITUARY NOTES.

CHARLES F. MURPHY, Inspector for the Water Department of Marlborough, Mass., was drowned on April 6, 1899, while crossing the ice on Fort Meadow Pond.

JAMES W. MORSE, Superintendent of Water Works, Natick, Mass., died on September 23, 1899, aged 68 years. He leaves a wife and three daughters.

Mr. Morse was a member of the committee which constructed the Natick water works, and upon their completion he was made superintendent, and he had held this office continuously, with the exception of one year, for about twenty-five years.

HENRY W. CONANT, Superintendent, Gardner, Mass., died November 18, 1899, of apoplexy.

HORACE B. WINSHIP, Civil Engineer, of Norwich, Conn., died in that city on November 8, 1899.

PRESIDENTS

OF THE

New England Water Works Association.

James W. Lyon, 1882–83.

Frank E. Hall, 1883–84.

George A. Ellis, 1884–85.

Robert C. P. Coggeshall, 1885–86.

Henry W. Rogers, 1886–87.

Edwin Darling, 1887–88.

Hiram Nevons, 1888–89.

Dexter Brackett, 1889–90.

Albert F. Noyes, 1890–91.

Horace G. Holden, 1891–92.

George F. Chace, 1892–93.

George E. Batchelder, 1893–94.

George A. Stacy, 1894–95.

Desmond Fitzgerald, 1895–96.

John C. Haskell, 1896–97.

Willard Kent, 1897–98.

Fayette F. Forbes, 1898–99.

Byron I. Cook, 1899——

New England Water Works Association

MEMBERSHIP ROLL.

SEPTEMBER 1, 1899.

Note.—The Secretary requests to be advised of existing errors or change of address from that which appears in the following list.

ACTIVE MEMBERS—RESIDENT AND NON-RESIDENT.

Abbot, Everett L.
230 [illegible]th Avenue, New York City.

Adams, John D.
Superintendent Provincetown, Mass.

Allen, Charles A.
Civil Engineer, 44 Front Street, Rooms 109 and 110 Worcester, Mass.

Allen, Charles F.
Treasurer, Hyde Park, Mass.

Allis, Solon M., C. E.
Bel Rock Street, Malden, Mass.

Andrews, Frank A.
Assistant Superintendent, Nashua, N. H.

Appleton, Francis E.
Paymaster Locks and Canals Company, Lowell, Mass.

Armstrong, S. G.
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Ashwell, William H.
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Babbidge, P. F.
Superintendent, Keene, N. H.

Babcock, Stephen E.
Chief Engineer, Little Falls, N. Y.

Bacot, R. C., Jr.
Superintendent Meter Department, P. O. Box 461 Port Chester, N. Y.

Badger, Frank S.
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Badger, Wm. E.
Assistant Engineer, Locks and Canals Company, Lowell, Mass.

Bagnell, Richard W.
Superintendent, Plymouth, Mass.

Bailey, E. W.
City Engineer, Somerville, Mass.

Bailey, Frank S.
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Bailey, George I.
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Baldwin, Charles H.
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Baldwin, Richard.
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Bancroft, Arthur G.
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Bancroft, Lewis M.
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Barbour, Frank A.
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Barnes, Roland D.
City Hall, Malden, Mass.

Barns, Everett.
Superintendent, Westerly, R. I.

Barrett, Albert P.
Woburn, Mass.

Barrus, George H.
Consulting Steam Engineer, 95 Milk Street, Boston, Mass.

Bartlett, Charles H.
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Bartlett, R. S.
Superintendent, Norwich, Conn.

Bassett, Carroll, Ph.
Treasurer Water Company, Summit, N. J.

Bassett, George B.
Civil Engineer, 363 Washington Street, Buffalo, N. Y.

Batchelder, George W.
Water Registrar, Worcester, Mass.

Batcheller, Francis.
Commissioner, North Brookfield, Mass.

Bates, Oren B.
Clinton, Mass.

Bates, Theodore C.
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City Engineer, 346 Jefferson Street, Milwaukee, Wis.

Berkey, John A.
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Bettes, Chas. R.
Chief Engineer Queen's County Water Company, Far Rockaway, N. Y.

Bickford, Nathan B.
61 Minot Street, Neponset, Mass.

Bigelow, James F.
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Billings, William R.
15 Harrison Street, Taunton, Mass.

Birkinbine, Henry.
General Manager Water and Gas Company, York, Pa.

Bisbee, Forrest E.
Superintendent, Auburn, Me.

Bishop, George H.
Civil Engineer, Middletown, Conn.

Bishop, Watson L.
Superintendent, Dartmouth, N. S.

Blackmer, James W., 2d.
Superintendent, Beverly, Mass.

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Civil Engineer, 19 Cottage Street, Providence, R. I.

Blossom, William L.
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Boggs, Edward M.
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Superintendent, Le Sueur, Minn.

Brinsmade, Daniel S.
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Brooks, E. C.
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Brown, J. Henry.
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Registrar, Bangor, Me.

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City Engineer, Martinville, Va.

Buckman, George A. P.
Superintendent, Norwood, Mass.

Burke, James E.
Superintendent Princeton Water Co., Princeton, N. J.

Burleigh, John M.
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Burnie, James.
Superintendent, Biddeford, Me.

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Superintendent, Pittsfield, Me.

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Butler, J. Allen.
Superintendent, Portland, Conn.

Cairns, R. A.
City Engineer, Waterbury, Conn.

Card, Huber D.
City Engineer, Willimantic, Conn.

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Cassell, George.
Superintendent Water Works, Chelsea, Mass.

Caulfield, John.
Secretary Water Works, St. Paul, Minn.

Cavanagh, John T.
Commissioner Public Works Quincy, Mass.

Chace, George F.
Superintendent, Taunton, Mass.

Chadbourne, E. J.
Superintendent, Wakefield, Mass.

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Chandler, Henry.
Water Commissioner, Manchester, N. H.

Chapin, G. L.
Water Commissioner, Lincoln, Mass.

Chapman, Benjamin R.
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Chief Engineer Water Works, Wilmington, N. C. Address, Derry, N. H.

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Superintendent, Newtown, N. Y.

Clark, A. D.
Secretary Spring Water Co., Kane, Pa.

Clark, D. W.
President Water Co., Portland, Me.

Clark, Frederic.
Water Commissioner, North Billerica, Mass.

Clark, Frederick W.
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Clark, Harry W.
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Inspector, Brockton, Mass.

Collins, Lewis P.
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Colson, Charles D.
Water Commissioner, Holyoke, Mass.

Conant, H. W.
Superintendent, Gardner, Mass.

Conant, Whitney.
Secretary Water Co., Long Branch, N. J.

Connell, Michael A.
Superintendent, St. Hyacinthe, P. Q.

Cook, Byron I.
Superintendent, Woonsocket, R. I.

Cook, Henry A.
Superintendent, Salem, Mass.

Cram, Arthur N.
Water Commissioner, Walpole, Mass.

Crandall, F. H.
Superintendent and Treasurer, Burlington, Vt.

Crandall, George K.
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Davis, J. M.
Rutland, Vt.

Davis, William E.
Superintendent, Sherburne, N. Y.

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Dean, Seth.
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Doran, Hugh F.
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Drake, B. Frank.
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Drown, Thomas M.
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Dunbar, E. L.
Superintendent, Bay City, Mich.

Dyer, Eben R.
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Quincy, Mass.

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Fitch, Jasper A.
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Forbes, Murray.
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Forbes, Z. R.
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Gardner, L. H.
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Gilderson, D. H.
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Inspector, Marlboro, Mass.

Gleason, J. F.
Foreman, Quincy, Mass.

Gleason, T. C.
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Gould, J. A.
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Greaney, Thomas F.
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Greene, S. C.
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Greetham, H. W.
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Hart, Edward W.
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City Engineer, Fitchburg, Mass.

Haskell, John C.
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Hastings, V. C.
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Hyde, Horatio N.
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Judkins, Fred G.
Franklin Falls, N. H.

Junkins, George S.
Water Commissioner, Lawrence, Mass.

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Kent, Willard.
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Kieran, Patrick.
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Kuehn, Jacob L.
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Kuichling, Emil.
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Laforest, J. O. Alfred.
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Learned, Wilbur F.
Civil Engineer, Watertown, Mass.

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Foreman, Brockton, Mass.

Lord, Harry A.
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Superintendent. Office, 104 River Street, Fitchburg, Mass.

Luce, Francis H.
Superintendent, Woodshaven, N. Y.

Lunt, Cyrus M.
Superintendent, Lewiston, Me.

Lusk, James L.
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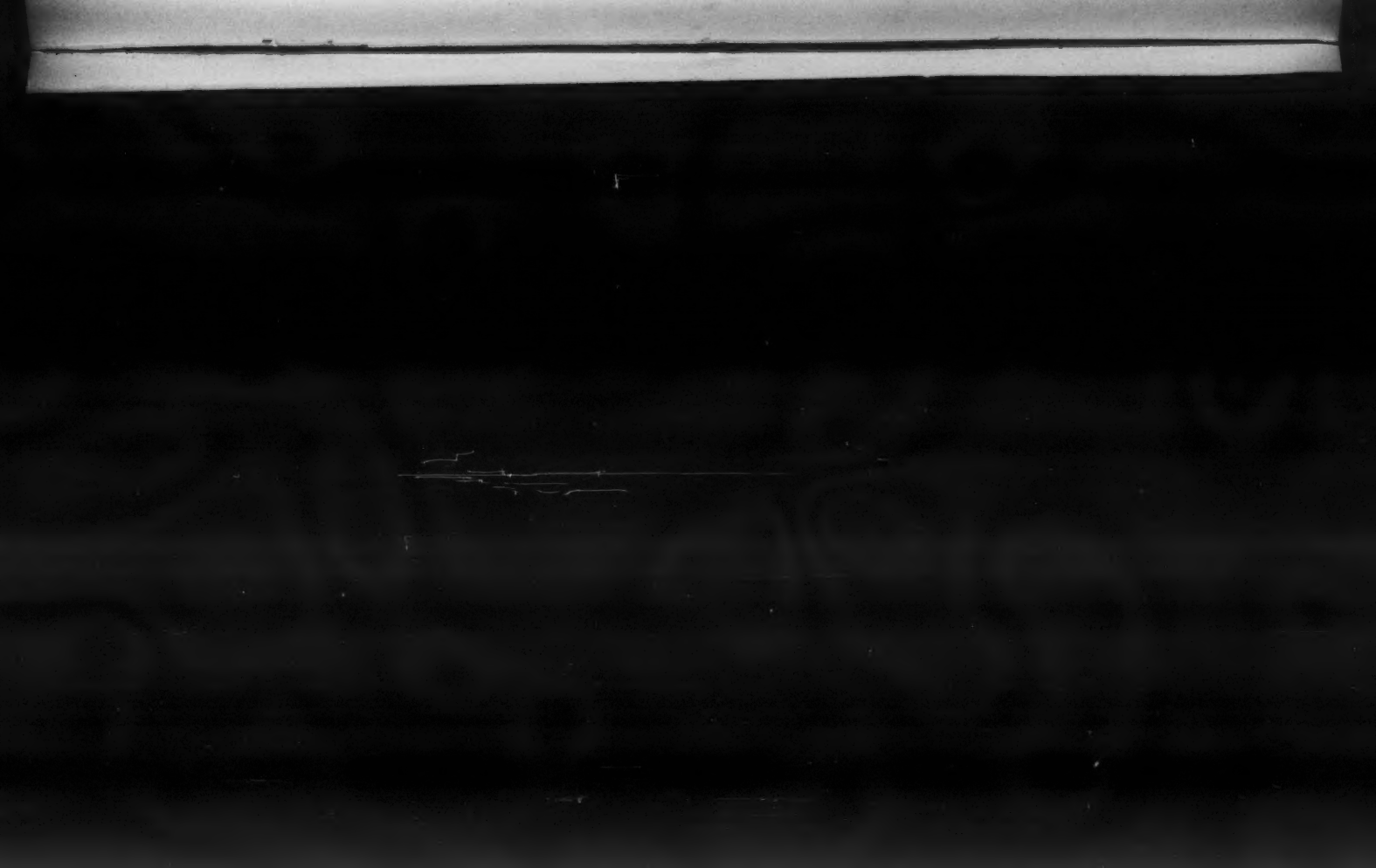

Table of Contents.

Page

Paper. "The Hydraulic Laboratory of Cornell University," by E. A. Fuertes 195

Paper. "The Buffalo, N. Y., Water Works," by Louis H. Knapp 206

Discussion by Messrs. Geo. B. Bassett, J. C. Whitney, and the Author 211

Paper. "The Method of Removing Organisms from the Water in the Distributing Reservoir of the City of Syracuse, N. Y.," by Wm. R. Hill 213

Discussion by Messrs. F. F. Forbes, J. C. Haskell, J. B. Fish, Allen Hazen, H. C. Hodgkins, and the Author 216

Paper. "On Removing Organisms from Water — A Discussion," by Frederick S. Hollis 221

Discussion by Messrs. H. R. Hill, R. S. Weston, J. C. Haskell, Horatio N. Parker, R. C. P. Coggeshall, and the Author 223

Paper. "A Rumpus in Collecting Meter Rates — Causes and Consequences," by George F. Chace 230

Discussion by Mr. J. C. Gilbert 238

Paper. "The Glasgow Water Works," by James M. Gale 240

Paper. "Covered Reservoirs and their Design," by Freeman C. Coffin 252

Proceedings 286

Attendance 286, 287, 289

Election of Members 287, 288, 290

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Plate I.